Computational details for the paper (Part 2): "Application of benchmark analysis for mixed contaminant exposures: Mutual adjustment of perfluoroalkylate substances associated with immunotoxicity"

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Introduction

This document contains computational details of results in two tables of Budtz-Jørgensen and Grandjean (2018). Thus, we provide SAS output and SAS programs for the linear models in Table 1 & 2. This document is a supplement to a similar report from 2020, where focus where on the results for PFHXS, PFNA and PFDA. This report is focused on PFOS and PFOA.

If the exposure slope is positive, the BMD is not defined. In this case BMD=10000 in the program. If the exposure slope is significantly positive (at a 10% level) then the BMDL is not defined. In this case BMDL=10000 in the program.

SAS output

The following pages show SAS-output from the two SAS-programs provided in section *SAS programs.* The output is from regression models with corresponding BMD results. The regression models are run with the procedure PROC REG in SAS. In the regression results, the exposure coefficient is always called *eksp.* However, in the title of the output (line 1) the exposure variable is given.

Table 1

Variable names

- log2_tet7: log2 of tetanus concentration at age 7
- log2_dif7: log2 of diphtheria concentration at age 7
- sex: childs sex
- age7: age at 7 year examination
- bosm: booster type at age 5
- pfos5: PFOS concentration at age 5
- pfoa5: PFOA concentration at age 5

- log2pfos60: log2 of PFOS concentration at age 5
- log2pfoa60: log2 of PFOA concentration at age 5

eksp is pfos5 11:34 Sunday, February 6, 2022 151

The REG Procedure
Model: MODEL1
Dependent Variable: log2_tet7

Number of Observations Read	548
Number of Observations Used	408
Number of Observations with Missing Values	140

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	42.79700	10.69925	2.67	0.0321
Error	403	1617.47391	4.01358		
Corrected Total	407	1660.27091			

Root MSE	2.00339	R-Square	0.0258
Dependent Mean	0.71684	Adj R-Sq	0.0161
Coeff Var	279.47654		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	90% Confidence Limits	
Intercept	1	-5.19061	7.84715	-0.66	0.5087	-18.12775	7.74654
eksp	1	-0.02741	0.01764	-1.55	0.1209	-0.05649	0.00167
sex	1	-0.55344	0.19931	-2.78	0.0057	-0.88202	-0.22485
age7	1	0.88893	1.02914	0.86	0.3882	-0.80775	2.58562
bosm	1	-0.04382	0.25295	-0.17	0.8625	-0.46084	0.37320

The REG Procedure
Model: MODEL1
Dependent Variable: log2_tet7

Number of Observations Read	548
Number of Observations Used	408
Number of Observations with Missing Values	140

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	68.88516	13.77703	3.48	0.0043
Error	402	1591.38575	3.95867		
Corrected Total	407	1660.27091			

Root MSE	1.98964	R-Square	0.0415
Dependent Mean	0.71684	Adj R-Sq	0.0296
Coeff Var	277.55812		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	90% Confidence Limits	
Intercept	1	-3.79917	7.81211	-0.49	0.6270	-16.67862	9.08029
eksp	1	-0.00390	0.01977	-0.20	0.8438	-0.03649	0.02870
sex	1	-0.58347	0.19828	-2.94	0.0034	-0.91037	-0.25656
age7	1	0.81231	1.02251	0.79	0.4274	-0.87345	2.49808
bosm	1	-0.00689	0.25162	-0.03	0.9782	-0.42172	0.40795
log2pfoa60	1	-0.61685	0.24029	-2.57	0.0106	-1.01300	-0.22070

The REG Procedure
Model: MODEL1
Dependent Variable: log2_tet7

Number of Observations Read	548
Number of Observations Used	408
Number of Observations with Missing Values	140

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	71.80731	17.95183	4.55	0.0013
Error	403	1588.46359	3.94160		
Corrected Total	407	1660.27091			

Root MSE	1.98535	R-Square	0.0433
Dependent Mean	0.71684	Adj R-Sq	0.0338
Coeff Var	276.95891		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	90% Confidence Limits	
Intercept	1	-3.84913	7.79182	-0.49	0.6216	-16.69506	8.99680
eksp	1	-0.19725	0.06295	-3.13	0.0019	-0.30103	-0.09347
sex	1	-0.58928	0.19776	-2.98	0.0031	-0.91532	-0.26324
age7	1	0.75516	1.02079	0.74	0.4599	-0.92775	2.43808
bosm	1	0.00945	0.24266	0.04	0.9689	-0.39061	0.40951

The REG Procedure
Model: MODEL1
Dependent Variable: log2_tet7

Number of Observations Read	548
Number of Observations Used	408
Number of Observations with Missing Values	140

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	72.53076	14.50615	3.67	0.0029
Error	402	1587.74015	3.94960		
Corrected Total	407	1660.27091			

Root MSE	1.98736	R-Square	0.0437
Dependent Mean	0.71684	Adj R-Sq	0.0318
Coeff Var	277.24002		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	90% Confidence Limits	
Intercept	1	-3.47624	7.84824	-0.44	0.6581	-16.41526	9.46279
eksp	1	-0.18455	0.06965	-2.65	0.0084	-0.29938	-0.06972
sex	1	-0.58541	0.19817	-2.95	0.0033	-0.91212	-0.25870
age7	1	0.75959	1.02188	0.74	0.4577	-0.92513	2.44431
bosm	1	-0.01981	0.25235	-0.08	0.9375	-0.43585	0.39622
log2pfos60	1	-0.10776	0.25178	-0.43	0.6689	-0.52285	0.30734

The REG Procedure
Model: MODEL1
Dependent Variable: log2_dif7

Number of Observations Read	548
Number of Observations Used	408
Number of Observations with Missing Values	140

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	50.29978	12.57494	3.66	0.0061
Error	403	1386.19174	3.43968		
Corrected Total	407	1436.49152			

Root MSE	1.85464	R-Square	0.0350
Dependent Mean	-0.52360	Adj R-Sq	0.0254
Coeff Var	-354.20639		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	90% Confidence Limits	
Intercept	1	-1.34852	7.26448	-0.19	0.8528	-13.32506	10.62802
eksp	1	-0.03219	0.01633	-1.97	0.0494	-0.05911	-0.00527
sex	1	-0.51464	0.18451	-2.79	0.0055	-0.81882	-0.21045
age7	1	0.20183	0.95272	0.21	0.8323	-1.36887	1.77254
bosm	1	0.20949	0.23416	0.89	0.3715	-0.17656	0.59554

The REG Procedure
Model: MODEL1
Dependent Variable: log2_dif7

Number of Observations Read	548
Number of Observations Used	408
Number of Observations with Missing Values	140

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	56.57342	11.31468	3.30	0.0063
Error	402	1379.91810	3.43263		
Corrected Total	407	1436.49152			

Root MSE	1.85274	R-Square	0.0394
Dependent Mean	-0.52360	Adj R-Sq	0.0274
Coeff Var	-353.84323		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	90% Confidence Limits	
Intercept	1	-0.66618	7.27457	-0.09	0.9271	-12.65941	11.32706
eksp	1	-0.02065	0.01841	-1.12	0.2625	-0.05100	0.00969
sex	1	-0.52936	0.18464	-2.87	0.0044	-0.83377	-0.22495
age7	1	0.16426	0.95215	0.17	0.8631	-1.40551	1.73403
bosm	1	0.22760	0.23431	0.97	0.3319	-0.15869	0.61389
log2pfoa60	1	-0.30250	0.22375	-1.35	0.1772	-0.67139	0.06640

The REG Procedure
Model: MODEL1
Dependent Variable: log2_dif7

Number of Observations Read	548
Number of Observations Used	408
Number of Observations with Missing Values	140

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	52.70245	13.17561	3.84	0.0045
Error	403	1383.78907	3.43372		
Corrected Total	407	1436.49152			

Root MSE	1.85303	R-Square	0.0367
Dependent Mean	-0.52360	Adj R-Sq	0.0271
Coeff Var	-353.89928		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	90% Confidence Limits	
Intercept	1	-0.80322	7.27253	-0.11	0.9121	-12.79302	11.18658
eksp	1	-0.12590	0.05875	-2.14	0.0327	-0.22276	-0.02904
sex	1	-0.53952	0.18458	-2.92	0.0037	-0.84383	-0.23521
age7	1	0.11755	0.95276	0.12	0.9019	-1.45321	1.68831
bosm	1	0.29787	0.22649	1.32	0.1892	-0.07553	0.67127

The REG Procedure
Model: MODEL1
Dependent Variable: log2_dif7

Number of Observations Read	548
Number of Observations Used	408
Number of Observations with Missing Values	140

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	59.57933	11.91587	3.48	0.0043
Error	402	1376.91219	3.42515		
Corrected Total	407	1436.49152			

Root MSE	1.85072	R-Square	0.0415
Dependent Mean	-0.52360	Adj R-Sq	0.0296
Coeff Var	-353.45762		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	90% Confidence Limits	
Intercept	1	0.34645	7.30863	0.05	0.9622	-11.70294	12.39584
eksp	1	-0.08673	0.06486	-1.34	0.1819	-0.19367	0.02020
sex	1	-0.52760	0.18454	-2.86	0.0045	-0.83184	-0.22335
age7	1	0.13121	0.95162	0.14	0.8904	-1.43768	1.70010
bosm	1	0.20763	0.23500	0.88	0.3775	-0.17980	0.59507
log2pfos60	1	-0.33223	0.23447	-1.42	0.1573	-0.71878	0.05433

eksp is pfoa5 11:34 Sunday, February 6, 2022 159

Obs	dependentny	exposure	model	adjust	bmd	bmdl
1	tetanus	pfos5	linear	no	2.699	1.310
2	tetanus	pfos5	linear	yes	18.99	2.028
3	tetanus	pfoa5	linear	no	0.375	0.246
4	tetanus	pfoa5	linear	yes	0.401	0.247
5	diphtheria	pfos5	linear	no	2.299	1.252
6	diphtheria	pfos5	linear	yes	3.583	1.451
7	diphtheria	pfoa5	linear	no	0.588	0.332
8	diphtheria	pfoa5	linear	yes	0.853	0.382

Table 2 results

Variable names

- ltet51: log2 of tetanus concentration at age 5
- ldif51: log2 of diphtheria concentration at age 5

- sex: childs sex
- age5a: age at 5 year examination
- cohort5: binary variable allowing for difference between cohorts
- vsex: interaction term between cohort and sex
- vage: interaction term between cohort and age
- matpfos: maternal concentration of PFOS
- matpfoa: maternal concentration of PFOA
- lmatpfos: log2 maternal concentration of PFOS
- lmatpfoa: log2 maternal concentration of PFOA

eksp is matpfos 11:34 Sunday, February 6, 2022 160

The REG Procedure
Model: MODEL1
Dependent Variable: ltet51

Number of Observations Read	900
Number of Observations Used	852
Number of Observations with Missing Values	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	114.93597	19.15600	5.46	<.0001
Error	845	2967.25281	3.51154		
Corrected Total	851	3082.18878			

Root MSE	1.87391	R-Square	0.0373
Dependent Mean	-2.49439	Adj R-Sq	0.0305
Coeff Var	-75.12514		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	-9.16706	7.22929	-1.27	0.2051
eksp		1	-0.01021	0.00953	-1.07	0.2841
sex		1	-0.22729	0.16682	-1.36	0.1734
AGE5A	Age, first 5yr exam	1	1.48445	1.45399	1.02	0.3076
cohort5		1	7.72292	10.67104	0.72	0.4694
vsex		1	0.47602	0.26282	1.81	0.0705
vage		1	-1.78049	2.13265	-0.83	0.4040

Parameter Estimates

Variable	Label	DF	90% Confidence Limits	
Intercept	Intercept	1	-21.07123	2.73711
eksp		1	-0.02590	0.00547
sex		1	-0.50199	0.04740

AGE5A	Age, first 5yr exam	1	-0.90978	3.87868
cohort5		1	-9.84865	25.29449
vsex		1	0.04325	0.90880
vage		1	-5.29223	1.73125

The REG Procedure
Model: MODEL1
Dependent Variable: ltet51

Number of Observations Read	900
Number of Observations Used	852
Number of Observations with Missing Values	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	136.55307	19.50758	5.59	<.0001
Error	844	2945.63571	3.49009		
Corrected Total	851	3082.18878			

Root MSE	1.86818	R-Square	0.0443
Dependent Mean	-2.49439	Adj R-Sq	0.0364
Coeff Var	-74.89532		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	-9.51164	7.20850	-1.32	0.1874
eksp		1	0.00207	0.01070	0.19	0.8468
sex		1	-0.19749	0.16674	-1.18	0.2366
AGE5A	Age, first 5yr exam	1	1.57766	1.45003	1.09	0.2769
cohort5		1	7.29639	10.63978	0.69	0.4930
vsex		1	0.39433	0.26406	1.49	0.1357
vage		1	-1.71268	2.12630	-0.81	0.4208
lpfoamat		1	-0.28943	0.11629	-2.49	0.0130

Parameter Estimates

Variable	Label	DF	90% Confidence Limits	
Intercept	Intercept	1	-21.38160	2.35832
eksp		1	-0.01555	0.01969
sex		1	-0.47206	0.07707
AGE5A	Age, first 5yr exam	1	-0.81004	3.96537
cohort5		1	-10.22372	24.81650
vsex		1	-0.04049	0.82915
vage		1	-5.21397	1.78862
lpfoamat		1	-0.48092	-0.09793

The REG Procedure
Model: MODEL1
Dependent Variable: ltet51

Number of Observations Read	900
Number of Observations Used	852
Number of Observations with Missing Values	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	128.12521	21.35420	6.11	<.0001
Error	845	2954.06357	3.49593		
Corrected Total	851	3082.18878			

Root MSE	1.86974	R-Square	0.0416
Dependent Mean	-2.49439	Adj R-Sq	0.0348
Coeff Var	-74.95799		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	-9.22293	7.17108	-1.29	0.1988
eksp		1	-0.13448	0.06059	-2.22	0.0267
sex		1	-0.19793	0.16624	-1.19	0.2341
AGE5A	Age, first 5yr exam	1	1.52552	1.44628	1.05	0.2918
cohort5		1	7.65916	10.61066	0.72	0.4706
vsex		1	0.41778	0.26267	1.59	0.1121
vage		1	-1.77160	2.12300	-0.83	0.4042

Parameter Estimates

Variable	Label	DF	90% Confidence Limits	
Intercept	Intercept	1	-21.03125	2.58538
eksp		1	-0.23425	-0.03472
sex		1	-0.47166	0.07580
AGE5A	Age, first 5yr exam	1	-0.85600	3.90705
cohort5		1	-9.81298	25.13129
vsex		1	-0.01475	0.85031
vage		1	-5.26746	1.72427

The REG Procedure
Model: MODEL1
Dependent Variable: ltet51

Number of Observations Read	900
Number of Observations Used	852
Number of Observations with Missing Values	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	128.39220	18.34174	5.24	<.0001
Error	844	2953.79658	3.49976		
Corrected Total	851	3082.18878			

Root MSE	1.87076	R-Square	0.0417
Dependent Mean	-2.49439	Adj R-Sq	0.0337
Coeff Var	-74.99900		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	-8.97422	7.23128	-1.24	0.2149
eksp		1	-0.12565	0.06854	-1.83	0.0671
sex		1	-0.20117	0.16674	-1.21	0.2280
AGE5A	Age, first 5yr exam	1	1.50746	1.44855	1.04	0.2983
cohort5		1	7.36551	10.66956	0.69	0.4902
vsex		1	0.42391	0.26375	1.61	0.1084
vage		1	-1.72420	2.13108	-0.81	0.4187
lpfosmat		1	-0.03925	0.14212	-0.28	0.7825

Parameter Estimates

Variable	Label	DF	90% Confidence Limits	
Intercept	Intercept	1	-20.88170	2.93325
eksp		1	-0.23852	-0.01278
sex		1	-0.47574	0.07339
AGE5A	Age, first 5yr exam	1	-0.87780	3.89273
cohort5		1	-10.20364	24.93467
vsex		1	-0.01039	0.85821
vage		1	-5.23338	1.78497
lpfosmat		1	-0.27327	0.19477

The REG Procedure
Model: MODEL1
Dependent Variable: ldif51

Number of Observations Read	900
Number of Observations Used	853
Number of Observations with Missing Values	47

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	123.44086	20.57348	5.33	<.0001
Error	846	3268.39631	3.86335		
Corrected Total	852	3391.83717			

Root MSE	1.96554	R-Square	0.0364
Dependent Mean	-3.09935	Adj R-Sq	0.0296
Coeff Var	-63.41783		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	2.69196	7.58623	0.35	0.7228
eksp		1	-0.03102	0.01000	-3.10	0.0020
sex		1	-0.59958	0.17476	-3.43	0.0006
AGE5A	Age, first 5yr exam	1	-0.92840	1.52558	-0.61	0.5430
cohort5		1	16.17874	11.19556	1.45	0.1488
vsex		1	1.07867	0.27553	3.91	<.0001
vage		1	-3.43306	2.23738	-1.53	0.1253

Parameter Estimates

Variable	Label	DF	90% Confidence Limits	
Intercept	Intercept	1	-9.79996	15.18387
eksp		1	-0.04748	-0.01456
sex		1	-0.88735	-0.31181
AGE5A	Age, first 5yr exam	1	-3.44050	1.58371
cohort5		1	-2.25650	34.61399
vsex		1	0.62497	1.53238
vage		1	-7.11726	0.25114

The REG Procedure
Model: MODEL1
Dependent Variable: ldif51

Number of Observations Read	900
Number of Observations Used	853
Number of Observations with Missing Values	47

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	130.26247	18.60892	4.82	<.0001
Error	845	3261.57470	3.85985		
Corrected Total	852	3391.83717			

Root MSE	1.96465	R-Square	0.0384
Dependent Mean	-3.09935	Adj R-Sq	0.0304
Coeff Var	-63.38909		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	2.50196	7.58414	0.33	0.7416
eksp		1	-0.02409	0.01127	-2.14	0.0328
sex		1	-0.58373	0.17508	-3.33	0.0009
AGE5A	Age, first 5yr exam	1	-0.87696	1.52538	-0.57	0.5655
cohort5		1	15.93644	11.19197	1.42	0.1548
vsex		1	1.03370	0.27748	3.73	0.0002
vage		1	-3.39428	2.23656	-1.52	0.1295
lpfoamat		1	-0.16245	0.12220	-1.33	0.1841

Parameter Estimates

Variable	Label	DF	90% Confidence Limits	
Intercept	Intercept	1	-9.98652	14.99045
eksp		1	-0.04265	-0.00554
sex		1	-0.87204	-0.29543
AGE5A	Age, first 5yr exam	1	-3.38873	1.63482
cohort5		1	-2.49292	34.36580
vsex		1	0.57679	1.49061
vage		1	-7.07713	0.28857
lpfoamat		1	-0.36368	0.03877

The REG Procedure
Model: MODEL1
Dependent Variable: ldif51

Number of Observations Read	900
Number of Observations Used	853
Number of Observations with Missing Values	47

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	98.51603	16.41934	4.22	0.0003
Error	846	3293.32114	3.89281		
Corrected Total	852	3391.83717			

Root MSE	1.97302	R-Square	0.0290
Dependent Mean	-3.09935	Adj R-Sq	0.0222
Coeff Var	-63.65918		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	0.54195	7.56860	0.07	0.9429
eksp		1	-0.11323	0.06380	-1.77	0.0763
sex		1	-0.54914	0.17517	-3.13	0.0018
AGE5A	Age, first 5yr exam	1	-0.60087	1.52633	-0.39	0.6939
cohort5		1	18.58939	11.19797	1.66	0.0973
vsex		1	1.00016	0.27698	3.61	0.0003
vage		1	-3.82897	2.24048	-1.71	0.0878

Parameter Estimates

Variable	Label	DF	90% Confidence Limits	
Intercept	Intercept	1	-11.92094	13.00484
eksp		1	-0.21829	-0.00818
sex		1	-0.83758	-0.26070
AGE5A	Age, first 5yr exam	1	-3.11421	1.91248
cohort5		1	0.15018	37.02860
vsex		1	0.54407	1.45626
vage		1	-7.51827	-0.13967

The REG Procedure
Model: MODEL1
Dependent Variable: ldif51

Number of Observations Read	900
Number of Observations Used	853
Number of Observations with Missing Values	47

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	123.15360	17.59337	4.55	<.0001
Error	845	3268.68357	3.86826		
Corrected Total	852	3391.83717			

Root MSE	1.96679	R-Square	0.0363
Dependent Mean	-3.09935	Adj R-Sq	0.0283
Coeff Var	-63.45813		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	2.95387	7.60499	0.39	0.6978
eksp		1	-0.02852	0.07191	-0.40	0.6918
sex		1	-0.57925	0.17502	-3.31	0.0010
AGE5A	Age, first 5yr exam	1	-0.77869	1.52314	-0.51	0.6093
cohort5		1	15.74519	11.21935	1.40	0.1609
vsex		1	1.05798	0.27706	3.82	0.0001
vage		1	-3.36909	2.24082	-1.50	0.1331
lpfosmat		1	-0.37725	0.14948	-2.52	0.0118

Parameter Estimates

Variable	Label	DF	90% Confidence Limits	
Intercept	Intercept	1	-9.56895	15.47669
eksp		1	-0.14694	0.08990
sex		1	-0.86744	-0.29105
AGE5A	Age, first 5yr exam	1	-3.28679	1.72941
cohort5		1	-2.72925	34.21963
vsex		1	0.60176	1.51420
vage		1	-7.05896	0.32078
lpfosmat		1	-0.62339	-0.13110

eksp is matpfoa 11:34 Sunday, February 6, 2022 168

Obs	dependentny	exposure	model	adjust	bmd	bmdl
1	tetanus	matpfos	linear	no	7.247	2.858
2	tetanus	matpfos	linear	yes	10000	4.758
3	tetanus	matPFOA	linear	no	0.550	0.316
4	tetanus	matPFOA	linear	yes	0.589	0.310
5	diphtheria	matpfos	linear	no	2.386	1.559
6	diphtheria	matpfos	linear	yes	3.071	1.735
7	diphtheria	matPFOA	linear	no	0.654	0.339
8	diphtheria	matPFOA	linear	yes	2.595	0.504

SAS programs

Table 1

```
DATA Temp;
  Set sasdat.bmd17;
RUN;

%macro drlinje1(respons, ekspo);

data tempi;
set temp;
eksp=&ekspo;
run;

proc reg data=tempi outest=esti0 tableout edf noprint;
model &ekspo = ;
run;

data esti0;
set esti0;
if _TYPE_='PARMS';
keep _DEPVAR_;
run;

data esti0;
set esti0;
exposure=_DEPVAR_;
keep exposure;
run;

proc means data=tempi p25 noprint;
var eksp;
output out=c p25=p25;
run;

data c;
set c;
CALL SYMPUT("p25",p25);
run;
```

```
proc reg data=tempi;
model &respons = eksp sex age7 bosm  /clb alpha=0.1;
ods output ParameterEstimates=alfa0;
output out=esti_1 r=res;
title "eksp is &ekspo";
run;


data esti_1;
set esti_1;
keep res eksp;
run;


proc means data=esti_1 noprint;
var res;
output out=e1 n=n USS=sumres2;
run;

data e1;
set e1;
m2lnl=(n*log(sumres2/n)+n*log(2*3.14159265)+n);
keep  m2lnl n;
run;

proc means data=esti_1 noprint;
var res;
where eksp<&p25;
output out=e n=n1 USS=sumres21;
run;

data e;
set e;
low_m2lnl=n1*log(sumres21/n1)+n1*log(2*3.14159265)+n1;
run;
```

```
data alfa0;
set alfa0;
if Variable='eksp';
keep dependent estimate lowercl stderr probt;
run;

data alfa0;
merge esti0 alfa0 e e1;
model='linear      ';
metode='relative';
run;


data alfa0;
set alfa0;
do bmr=0.01 to 0.2 by 0.01;
output;
end;



data alfa0;
set alfa0;
bmd=log2(1-bmr)/estimate;
bmdl=log2(1-bmr)/lowercl;
run;

data alfa0;
set alfa0;
num+1;
run;


data alfa;
set alfa0;
keep bmr BMD BMDL estimate dependent exposure metode model num m2lnl low_m2lnl n1
probt;
```

```
run;

data alfa5;
set alfa;
if num=5;
run;

data alfa10;
set alfa;
if num=10;
bmd10=bmd;
bmdl10=bmdl;
keep bmd10 bmdl10;
run;

data al;
    merge alfa5 alfa10;
run;


data al;
merge al;
adjust="no ";
run;

data saml;
set saml al;
run;

%mend drlinje1;

%macro drlinje2(respons, ekspo,conf);

data tempi;
set temp;
eksp=&ekspo;
run;
```

```
proc reg data=tempi outest=esti0 tableout edf noprint;
model &ekspo = ;
run;

data esti0;
set esti0;
if _TYPE_='PARMS';
keep _DEPVAR_;
run;

data esti0;
set esti0;
exposure=_DEPVAR_;
keep exposure;
run;

proc means data=tempi p25 noprint;
var eksp;
output out=c p25=p25;
run;

data c;
set c;
CALL SYMPUT("p25",p25);
run;


proc reg data=tempi;
model &respons = eksp sex age7 bosm &conf &conf2 /clb alpha=0.1;
ods output ParameterEstimates=alfa0;
output out=esti_1 r=res;
title "eksp is &ekspo";
run;

data esti_1;
set esti_1;
keep res eksp;
run;
```

```
proc means data=esti_1 noprint;
var res;
output out=e1 n=n USS=sumres2;
run;

data e1;
set e1;
m2lnl=(n*log(sumres2/n)+n*log(2*3.14159265)+n);
keep  m2lnl n;
run;

proc means data=esti_1 noprint;
var res;
where eksp<&p25;
output out=e n=n1 USS=sumres21;
run;

data e;
set e;
low_m2lnl=n1*log(sumres21/n1)+n1*log(2*3.14159265)+n1;
run;



data alfa0;
set alfa0;
if Variable='eksp';
keep dependent estimate lowercl stderr probt;
run;

data alfa0;
merge esti0 alfa0 e e1;
model='linear      ';
metode='relative';
run;
```

```
data alfa0;
set alfa0;
do bmr=0.01 to 0.2 by 0.01;
output;
end;



data alfa0;
set alfa0;
bmd=log2(1-bmr)/estimate;
bmdl=log2(1-bmr)/lowercl;
run;

data alfa0;
set alfa0;
num+1;
run;


data alfa;
set alfa0;
keep bmr BMD BMDL estimate dependent exposure metode model num m2lnl low_m2lnl n1
probt;
run;

data alfa5;
set alfa;
if num=5;
run;

data alfa10;
set alfa;
if num=10;
bmd10=bmd;
bmdl10=bmdl;
keep bmd10 bmdl10;
```

```
run;

data al;
    merge alfa5 alfa10;
run;

proc reg data=tempi outest=estic tableout edf noprint;
model &conf = ;
run;

data estic;
set estic;
if _TYPE_='PARMS';
keep _DEPVAR_;
run;

data estic;
set estic;
confounder=_DEPVAR_;
keep confounder;
run;


proc reg data=tempi outest=estic2 tableout edf noprint;
model &conf2 = ;
run;

data estic2;
set estic2;
if _TYPE_='PARMS';
keep _DEPVAR_;
run;

data estic2;
set estic2;
confounder2=_DEPVAR_;
keep confounder2;
run;
```

```
data al;
merge al estic estic2;
adjust="yes ";
run;

data saml;
set saml al;
run;


%mend drlinje2;
data saml;
run;

%drlinje1(log2_tet7, pfos5);
%drlinje2(log2_tet7, pfos5,log2pfoa60);

%drlinje1(log2_tet7, pfoa5);
%drlinje2(log2_tet7, pfoa5,log2pfos60);

%drlinje1(log2_dif7, pfos5);
%drlinje2(log2_dif7, pfos5,log2pfoa60);

%drlinje1(log2_dif7, pfoa5);
%drlinje2(log2_dif7, pfoa5,log2pfos60);

data saml;
set saml;
if dependent='log2_tet7' then dependentny='tetanus   ';
if dependent='log2_dif7' then dependentny='diphtheria';
run;


data saml;
set saml;
format bmd bmdl bmd10 bmdl10 5.3;
format  m2lnl low_m2lnl 8.2;
```

```
format probt 6.4;
run;


data saml;
   set saml;
   if bmd=. then delete;
                if bmd<0 then bmd=10000;
   if bmd10<0 then bmd10=10000;
   keep dependentny exposure  model  adjust bmd  bmdl bmd10 bmdl10;
run;

proc print data=saml;
var  dependentny exposure  model  adjust bmd  bmdl;
run;
```

Table 2

```
libname sasdat1 "P:\compu18\efter\cohort5\sasdata";

data temp;
set sasdat1.sam35;
if age5a=. then delete;
vage=cohort5*age5a;
vsex=cohort5*sex;
run;

%macro drlinje1(respons, ekspo);

data tempi;
set temp;
eksp=&ekspo;
run;
```

```
proc reg data=tempi outest=esti0 tableout edf noprint;
model &ekspo = ;
run;

data esti0;
set esti0;
if _TYPE_='PARMS';
keep _DEPVAR_;
run;

data esti0;
set esti0;
exposure=_DEPVAR_;
keep exposure;
run;

proc means data=tempi p25 noprint;
var eksp;
output out=c p25=p25;
run;

data c;
set c;
CALL SYMPUT("p25",p25);
run;

proc reg data=tempi;
model &respons = eksp sex age5a cohort5 vsex vage /clb alpha=0.1;
ods output ParameterEstimates=alfa0;
output out=esti_1 r=res;
title "eksp is &ekspo";
run;

data esti_1;
set esti_1;
keep res eksp;
run;
```

```
proc means data=esti_1 noprint;
var res;
output out=e1 n=n USS=sumres2;
run;

data e1;
set e1;
m2lnl=(n*log(sumres2/n)+n*log(2*3.14159265)+n);
keep  m2lnl n;
run;

proc means data=esti_1 noprint;
var res;
where eksp<&p25;
output out=e n=n1 USS=sumres21;
run;

data e;
set e;
low_m2lnl=n1*log(sumres21/n1)+n1*log(2*3.14159265)+n1;
run;



data alfa0;
set alfa0;
if Variable='eksp';
keep dependent estimate lowercl stderr;
run;

data alfa0;
merge esti0 alfa0 e e1;
model='linear      ';
metode='relative';
run;
```

```
data alfa0;
set alfa0;
do bmr=0.01 to 0.2 by 0.01;
output;
end;



data alfa0;
set alfa0;
bmd=log2(1-bmr)/estimate;
bmdl=log2(1-bmr)/lowercl;
run;

data alfa0;
set alfa0;
num+1;
run;


data alfa;
set alfa0;
keep bmr BMD BMDL estimate dependent exposure metode model num m2lnl low_m2lnl n1;
run;

data alfa5;
set alfa;
if num=5;
run;

data alfa10;
set alfa;
if num=10;
bmd10=bmd;
bmdl10=bmdl;
keep bmd10 bmdl10;
run;
```

```
data al;
   merge alfa5 alfa10;
adjust="no ";
run;

data saml;
set saml al;
run;

%mend drlinje1;


%macro drlinje2(respons, ekspo,conf);

data tempi;
set temp;
eksp=&ekspo;
run;

proc reg data=tempi outest=esti0 tableout edf noprint;
model &ekspo = ;
run;

data esti0;
set esti0;
if _TYPE_='PARMS';
keep _DEPVAR_;
run;

data esti0;
set esti0;
exposure=_DEPVAR_;
keep exposure;
run;

proc means data=tempi p25 noprint;
var eksp;
output out=c p25=p25;
```

```
run;

data c;
set c;
CALL SYMPUT("p25",p25);
run;


proc reg data=tempi;
model &respons = eksp sex age5a cohort5 vsex vage  &conf/clb alpha=0.1;
ods output ParameterEstimates=alfa0;
output out=esti_1 r=res;
title "eksp is &ekspo";
run;

data esti_1;
set esti_1;
keep res eksp;
run;


proc means data=esti_1 noprint;
var res;
output out=e1 n=n USS=sumres2;
run;

data e1;
set e1;
m2lnl=(n*log(sumres2/n)+n*log(2*3.14159265)+n);
keep  m2lnl n;
run;

proc means data=esti_1 noprint;
var res;
where eksp<&p25;
output out=e n=n1 USS=sumres21;
run;
```

```
data e;
set e;
low_m2lnl=n1*log(sumres21/n1)+n1*log(2*3.14159265)+n1;
run;



data alfa0;
set alfa0;
if Variable='eksp';
keep dependent estimate lowercl stderr;
run;

data alfa0;
merge esti0 alfa0 e e1;
model='linear      ';
metode='relative';
run;


data alfa0;
set alfa0;
do bmr=0.01 to 0.2 by 0.01;
output;
end;

data alfa0;
set alfa0;
bmd=log2(1-bmr)/estimate;
bmdl=log2(1-bmr)/lowercl;
run;

data alfa0;
set alfa0;
num+1;
run;
```

```
data alfa;
set alfa0;
keep bmr BMD BMDL estimate dependent exposure metode model num m2lnl low_m2lnl n1;
run;

data alfa5;
set alfa;
if num=5;
run;

data alfa10;
set alfa;
if num=10;
bmd10=bmd;
bmdl10=bmdl;
keep bmd10 bmdl10;
run;

data al;
   merge alfa5 alfa10;
adjust="yes";
run;

data saml;
set saml al;
run;

%mend drlinje2;



data saml;
run;

%drlinje1(ltet51, matpfos);
%drlinje2(ltet51, matpfos,lpfoamat);

%drlinje1(ltet51, matpfoa);
```

```
%drlinje2(ltet51, matpfoa,lpfosmat);


%drlinje1(ldif51, matpfos);
%drlinje2(ldif51, matpfos,lpfoamat);

%drlinje1(ldif51, matpfoa);
%drlinje2(ldif51, matpfoa,lpfosmat);

data saml;
set saml;
if dependent='ltet51' then dependentny='tetanus   ';
if dependent='ldif51' then dependentny='diphtheria';
run;


data saml;
set saml;
format bmd bmdl bmd10 bmdl10 5.3;
format  m2lnl low_m2lnl 8.2;
format probt 6.4;
run;


data saml;
   set saml;
   if bmd=. then delete;
                if bmd<0 then bmd=10000;
                if bmdl<0 then bmdl=10000;
   if bmd10<0 then bmd10=10000;
   keep dependentny exposure  model  adjust bmd  bmdl bmd10 bmdl10;
run;

proc print data=saml;
var  dependentny exposure  model  adjust bmd  bmdl;
run;
```