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## EARLY NUTRITION

Long-term effects of early nutrition on later health

# Impact of maternal body mass index before pregnancy on growth trajectory patterns in childhood and body composition in young adulthood

WP10 working group of the Early Nutrition Project

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- These authors contributed equally and should both be considered as first authors
- None of the authors have a conflict of interest



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**EARLYNUTRITION**

Long-term effects of early nutrition on later health

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nutrition on later health  
(2012-2017)** FP7-289346-*EarlyNutrition*

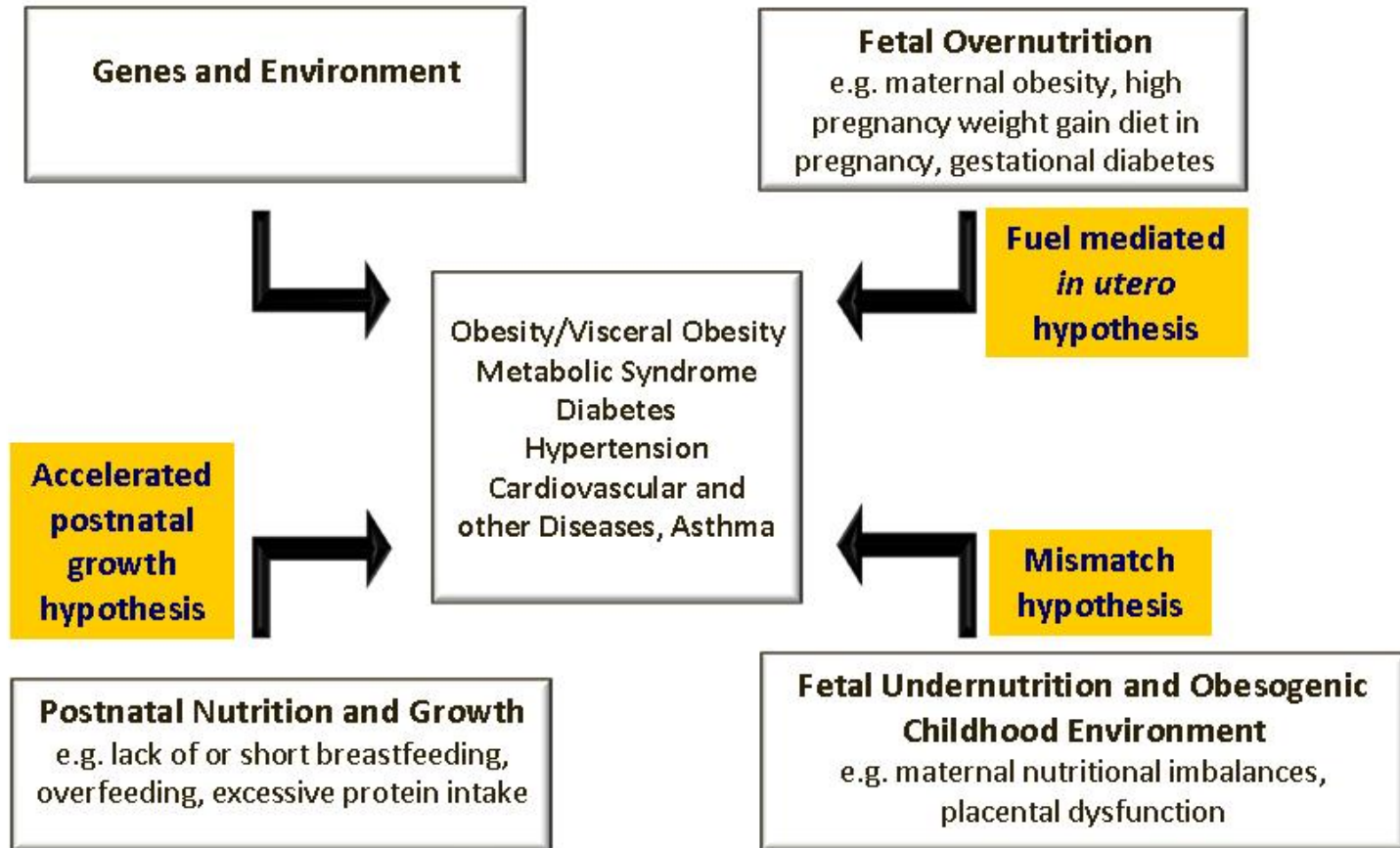
**36 research institutions, 16 countries, 3 continents**



***Budget >12 Mil €***

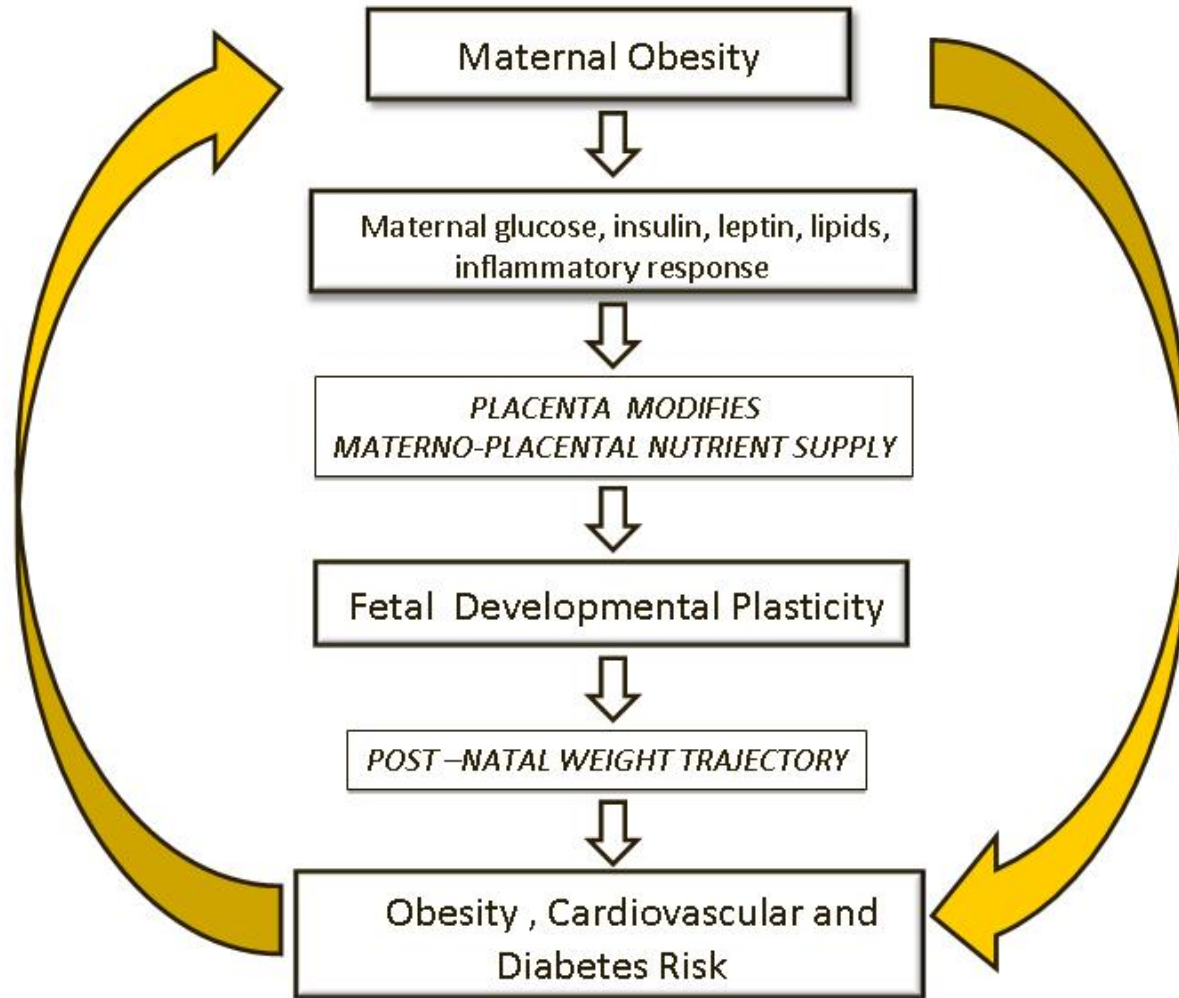
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NHMRC & industry partners*

# Key Hypotheses



*modified from Koletzko et al, Am J Clin Nutr, 2011 Dec;94(6):2036S-2043S.*

# Transgenerational Circle of Obesity



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*modified from Koletzko et al,  
Am J Clin Nutr, 2011  
Dec;94(6):2036S-2043S.*

Aim and objectives of this work were to test in a pooled analyses of 4 cohorts

**AIM:** to test the role of maternal body mass index before pregnancy in relation to programming of later growth and obesity risk in the child

**Objectives:**

- 1) identify groups of children with substantially different types of BMI-development/growth pattern in the first six years of life
- 2) whether maternal body mass index before pregnancy is associated with rapid growth pattern trajectories during childhood

Objectives of this work were to test in a pooled analyses of 4 cohorts (continued)

- 3) whether different types of growth patterns are reflected in measures of body composition such as skinfolds and fat mass at six years and
- 4) whether any differences in body composition among potential growth pattern groups continue into young adulthood (age 20 years)

# STUDY DESIGN/ STATISTICAL METHOD I:

- Pooled longitudinal analyses of all 4 cohorts
  - RAINE: *Australia*
  - CHOP: *Belgium, Germany, Spain, Italy, Poland*
  - HUMIS: *Norway*
  - PreventCD: *Germany, Spain, Croatia, Hungary, Israel, Italy, Netherlands, Poland*
- to identify type of BMI-SDS growth pattern over first 6 life years

# STUDY DESIGN/ STATISTICAL METHOD I:

- Objective was to assess
  - effect of *maternal Pre-Pregnancy weight status (BMI (kg/m<sup>2</sup>)) on the identified BMI-SDS patterns*
  - *effect of BMI-SDS patterns on distal outcomes of body composition (triceps +subscapular skinfolds , fat mass (kg) and FM index (FM/height (kg/m<sup>2</sup>)) at age 6 and 20 years)*
- *Adjusted for Covariates:*
  - duration of full breastfeeding (fully BF <3 vs 3+ months)
  - Gestational age (*weeks*)
  - Years of schooling (<12 vs. 12+ yrs)
  - any maternal smoking during pregnancy (y/n)



# STATISTICAL METHOD II:

- I. Identification of growth pattern classes & evaluation of some determinants
  
- II. Assessment of growth pattern classes on distal outcomes (skinfolds, fat mass) analyzed by special Latent Growth Mixture Modeling (LGMM)
  - I) via Vermunt's 3 step method implemented in Mplus (R3STEP) to enable
    - Identification of classification-error corrected BMI-SDS pattern classes in the presence of predictors and covariates
    - a valid assessment of predictor effects on identified growth patterns

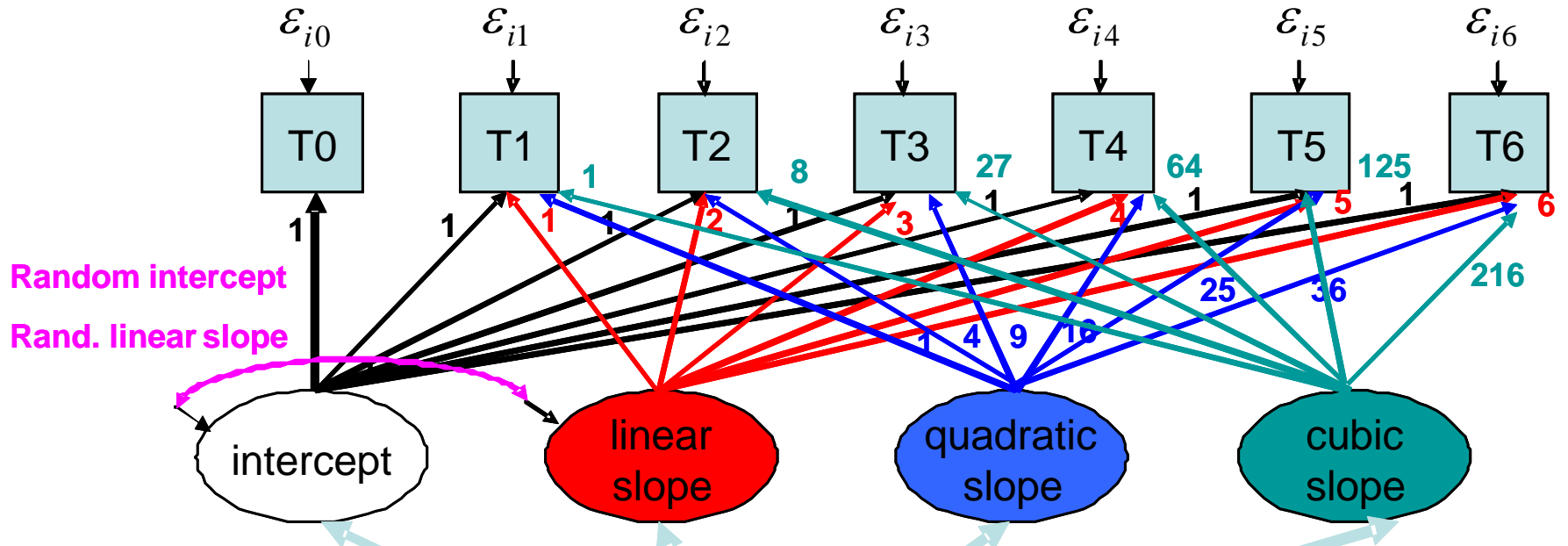
*Vermunt (2010), Bakk/Vermunt (2015), Asparouhov/Muthen (2014,2015)*

# STATISTICAL METHOD II:

- II) via Bakk/Vermunt 3 step method implemented in Mplus (BCH)  
to assess
- Differences in distal outcomes among identified BMI-SDS growth pattern classes (*e. g. mean differences in skinfolds or fat mass among children with different growth patterns by ANOVA/ Regression*)
  - with classification error-corrected classes and avoidance of class-changes

*Vermunt (2010), Bakk/Vermunt (2015), Asparouhov/Muthen (2014,2015)*

# Latent Growth Mixture Model



Overall probability & final size of the k latent trajectory classes

(e.q. 2): 
$$\Pr(C_i = k) = \frac{e^{\pi_{0k}}}{\sum_{k=1}^{k=3} e^{\pi_{0k}}}$$

Conditional probability for child's i to be assigned to latent class k given it's observed BMI- trajectory  $Y_{it}$

(e.q. 3): 
$$\hat{p}_{ik} = \hat{\Pr}(C_i = k | Y_i) = \frac{\hat{\Pr}(C_i = k) \hat{\Pr}(Y_i | C_i = k)}{\hat{\Pr}(Y_i)}$$

(e.q. 1): 
$$y_{it} = \eta_{0i} + \eta_{1i} \text{age}_t + \eta_{2i} \text{age}_t^2 + \eta_{3i} \text{age}_t^3 + \epsilon_{it}$$

$$V(\epsilon | C = k) = \Theta_k$$

$$\eta_{0i} = \alpha_{0k} + \zeta_{0i} \quad \eta_{1i} = \alpha_{1k} + \zeta_{1i} \quad \eta_{2i} = \alpha_{2k} + \zeta_{2i} \quad \eta_{3i} = \alpha_{3k} + \zeta_{3i}$$

$$V(\zeta | C = k) = \Psi_k$$

intercept

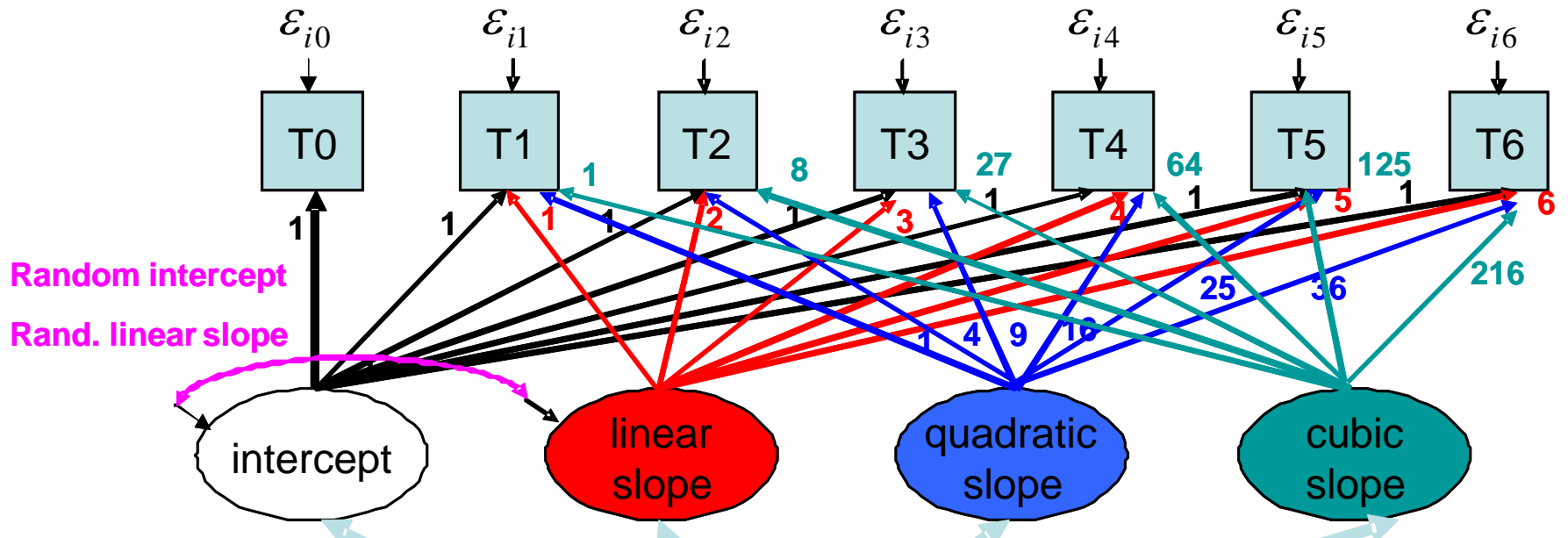
linear slope

quadratic slope

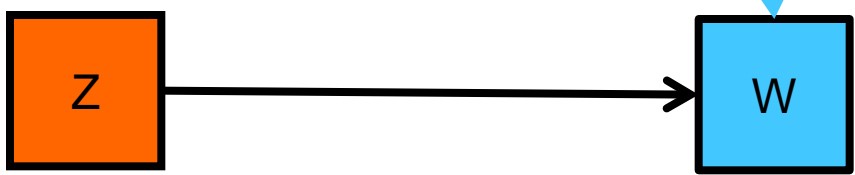
cubic slope

Variance given class

# LGMM – 3 Step Prediction Model



**Step 3:** Predicted class  $W$  is regressed on covariate  $Z$  by multinomial logistic regression



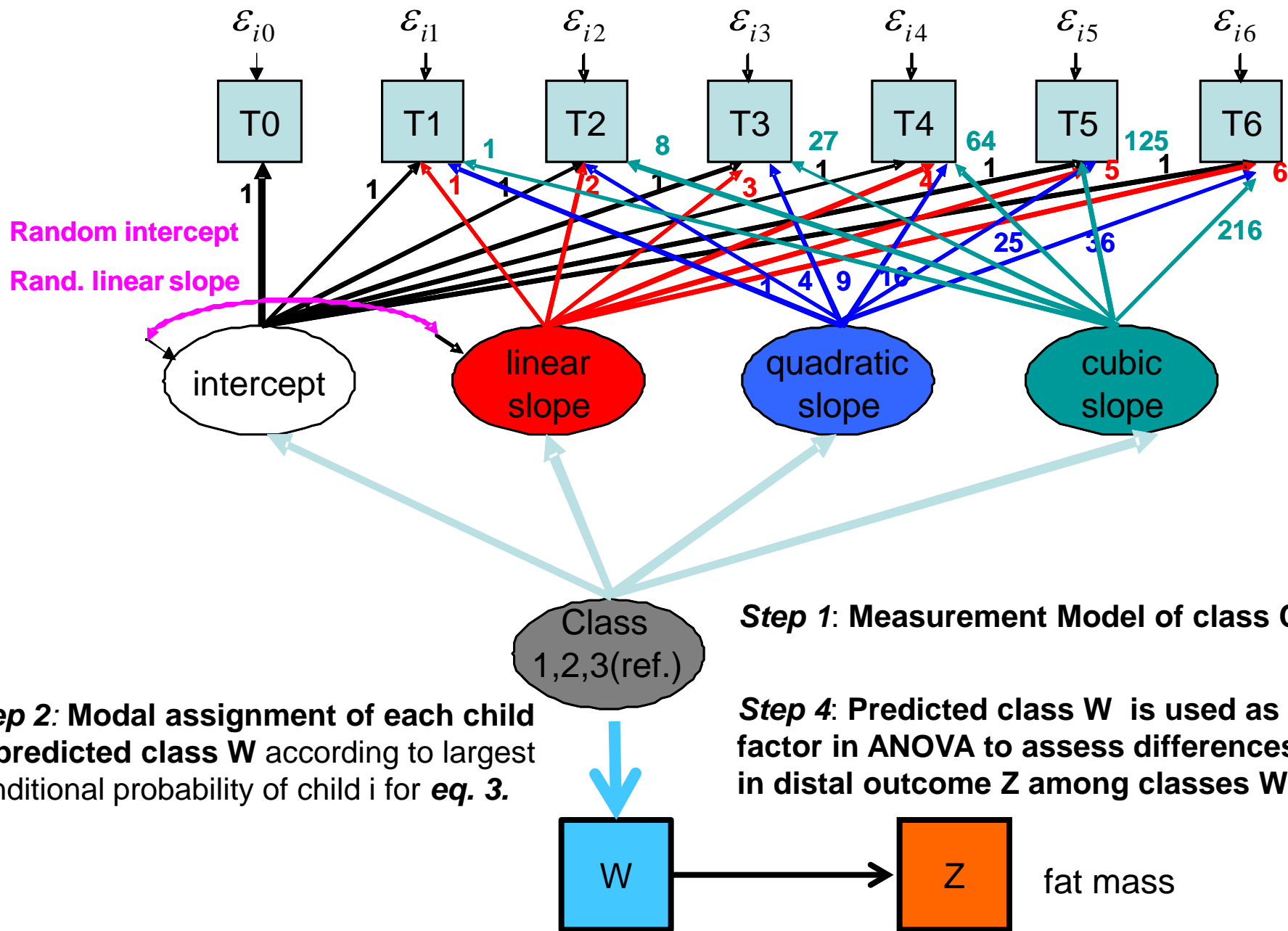
*Breastfeeding*

Class 1,2,3(ref.)

**Step 1:** Measurement Model of class  $C$

**Step 2:** Modal assignment of each child to predicted class  $W$  according to largest conditional probability of child  $i$  for *eq. 3*. That is prob for child  $i$  given that child's individual values of trajectory  $Y_{it}$

# LGMM – 3 Step Distal Outcome Model



# Characteristics of the 4 cohorts RAINE, CHOP, HUMIS & PreventCD

	RAINE			CHOP			HUMIS			PreventCD			TOTAL		
	n	mean or %	sd	n	mean or %	sd	n	mean or %	sd	n	mean or %	sd	n	mean or %	sd
<b>Child</b>															
% female	2440	49.0	-	1193	51.2	-	2230	47.3	-	845	48.8	-	6708	48.8	-
weight at birth (g)															
girls	1195	3247.5	549.0	611	3245.9	339.9	1055	3511.5	597.2	412	3260.0	447.7	3273	3333.9	535.4
boys	1245	3390.4	562.1	582	3357.3	353.6	1175	3621.1	629.0	433	3361.7	481.9	3435	3460.1	560.1
length at birth (cm)															
girls	1195	48.5	2.5	611	50.2	2.4	1055	49.6	2.5	412	50.4	2.8	3273	49.4	2.6
boys	1245	49.4	2.5	582	51.0	2.7	1175	50.4	2.7	433	51.0	2.8	3435	50.2	2.7
% exclusively breastfed (3+ months)	2282	43.7	-	1193	29.0	-	2128	84.1	-	797	55.0	-	6400	55.8	-
gestational age (wk)	2440	39.3	2.0	1192	39.8	1.2	2230	39.8	2.1	843	39.1	1.4	6705	39.6	1.9
<b>Mother</b>															
age at delivery (years)	2439	28.4	5.8	1192	30.4	5.0	2230	30.7	4.7	816	32.9	4.4	6677	30.1	5.4
pre-pregnancy BMI (kg/m <sup>2</sup> )	2271	22.3	4.2	1147	23.4	4.3	2173	24.3	4.5	168	22.2	3.0	5759	23.3	4.4
% obese pre-pregnancy (BMI≥30)	2271	6.1	-	1147	7.8	-	2173	10.9	-	168	3.0	-	5759	8.1	-
% high education (12+ years)	2440	44.1	-	1191	24.8	-	2215	91.7	-	0	-	-	5846	58.2	-
% any smoking in pregnancy	2267	38.6	-	1190	33.7	-	2204	11.1	-	0	-	-	5661	26.9	-

Note: Sample size was restricted to those participants who fulfill the inclusion criteria of this study as described in the method section. Briefly, population analyzed comprises those infants with at least 1 follow-up after birth within the first 6 years of life, valid BMI-SDS anthropometric measurements at age plus –minus 3 months of biannual measurements and with information on gender.

Similarities across the studies were for

- sex,
- birthweight
- birth length
- gestational age

and differences

- CHOP study babies breastfed less
- HUMIS babies heavier at birth, breastfed longer, mother BMI higher, greater education levels and smoke less
- Prevent CD mothers were slightly older with fewer obese mothers

# Anthropometric measurements of the four cohorts RAINE, CHOP, HUMIS and PreventCD

STUDY	birth		age 1 yr*		age 2 yr*		age 3 yr*		age 4 yr*		age 5 yr*		age 6 yr*	
	n	mean ± sd	n	mean ± sd	n	mean ± sd	n	mean ± sd	n	mean ± sd	n	mean ± sd	n	mean ± sd
<b>RAINE</b>														
BMI (Kg/m <sup>2</sup> ) - girls	1195	13.7 ± 1.6	1020	16.8 ± 1.4	268	16.0 ± 1.3	751	16.2 ± 1.4	0	-	374	15.9 ± 1.8	461	15.7 ± 1.8
BMI (Kg/m <sup>2</sup> ) - boys	1245	13.8 ± 1.5	1053	17.4 ± 1.4	279	16.4 ± 1.3	776	16.5 ± 1.3	0	-	423	15.8 ± 1.7	484	15.8 ± 1.7
BMI-SDS	2440	0.2 ± 1.2	2073	0.4 ± 0.9	547	0.2 ± 1.0	1527	0.6 ± 1.0	0	-	797	0.4 ± 1.1	945	0.2 ± 1.0
% BMI>90th pctl	2440	17.1	2073	17.8	547	12.6	1527	22.7	0	-	797	17.1	945	12.7
% BMI>97th pctl	2440	5.5	2073	5.8	547	4.9	1527	8.5	0	-	797	7.8	945	5.3
<b>CHOP</b>														
BMI (Kg/m <sup>2</sup> ) - girls	611	12.9 ± 1.2	550	17.0 ± 1.4	472	16.1 ± 1.2	385	15.9 ± 1.3	352	15.9 ± 1.3	343	15.9 ± 1.5	340	16.0 ± 1.8
BMI (Kg/m <sup>2</sup> ) - boys	582	12.9 ± 1.2	510	17.4 ± 1.6	435	16.3 ± 1.3	341	16.0 ± 1.4	312	15.9 ± 1.4	302	15.9 ± 1.7	301	16.0 ± 2.0
BMI-SDS	1193	-0.4 ± 1.0	1060	0.4 ± 1.0	907	0.3 ± 0.9	726	0.3 ± 1.0	664	0.4 ± 0.9	645	0.4 ± 1.0	641	0.3 ± 1.1
% BMI>90th pctl	1193	2.7	1060	19.2	907	14.0	726	15.0	664	14.2	645	16.0	641	16.7
% BMI>97th pctl	1193	0.3	1060	7.2	907	4.2	726	4.8	664	5.9	645	7.1	641	8.4
<b>HUMIS</b>														
BMI (Kg/m <sup>2</sup> ) - girls	1055	14.2 ± 1.6	826	16.8 ± 1.4	323	16.3 ± 1.6	220	15.8 ± 1.4	0	-	47	15.7 ± 1.5	35	15.5 ± 1.2
BMI (Kg/m <sup>2</sup> ) - boys	1175	14.1 ± 1.6	923	17.3 ± 1.4	342	16.5 ± 1.4	242	16.2 ± 1.5	0	-	55	15.9 ± 1.5	30	15.1 ± 1.4
BMI-SDS	2230	0.5 ± 1.2	1749	0.2 ± 0.9	665	0.4 ± 1.1	462	0.3 ± 1.1	0	-	102	0.3 ± 1.0	65	0.0 ± 0.9
% BMI>90th pctl	2230	25.6	1749	13.3	665	21.8	462	19.0	0	-	102	18.6	65	7.7
% BMI>97th pctl	2230	10.7	1749	3.5	665	7.8	462	8.22511	0	-	102	5.9	65	1.5
<b>PreventCD</b>														
BMI (Kg/m <sup>2</sup> ) - girls	412	12.8 ± 1.4	319	16.6 ± 1.5	267	16.1 ± 1.6	250	15.9 ± 1.8	158	15.6 ± 1.5	101	15.3 ± 1.6	52	15.2 ± 1.7
BMI (Kg/m <sup>2</sup> ) - boys	433	12.9 ± 1.5	349	17.1 ± 1.5	298	16.3 ± 1.3	279	15.9 ± 1.4	177	15.7 ± 1.4	96	15.6 ± 1.5	70	15.3 ± 1.4
BMI-SDS	845	-0.5 ± 1.2	668	0.1 ± 1.0	565	0.3 ± 1.1	529	0.2 ± 1.1	335	0.2 ± 1.0	197	0.1 ± 1.0	122	-0.1 ± 1.1
% BMI>90th pctl	845	6.2	668	13.0	565	14.5	529	15.1	335	13.7	197	13.7	122	8.2
% BMI>97th pctl	845	1.7	668	3.9	565	5.7	529	7.4	335	6.0	197	4.6	122	4.1

\* years plus-minus 3 months, Note: Full table with all biannual measurements is listed in online supplemental material table E1



## Test statistics to determine number of BMI-SDS derived growth pattern classes and model fit

No of classes	model specification		sample-size adjusted		adjusted		
	random	fix	BIC		Lo-Mendell-Rubin-Test		
			Value	# of estimates	Value	<i>P</i> -value	Entropy
1	i, s	q, k	77746	20	n.a	n.a	n.a
2	i, s	q, k	77055	25	703	0.0000	0.30
<b>3</b>	<b>i, s</b>	<b>q, k</b>	<b>76670</b>	<b>30</b>	<b>404</b>	<b>0.0007</b>	<b>0.49</b>
4	i, s	q, k	76504	35	189	0.0020	0.60

**Note:** The LGMM to identify BMI-SDS growth pattern classes was based on all 4 cohorts (RAINE, CHOP, HUMIS, PreventCD) with predictors and covariates as auxiliary variables (see model M2, table 4).

The model was estimated by the modal ML method of Vermunt (2010) implemented in Mplus as R3STEP option for the predictor and covariates to ensure classification-error corrected BMI-SDS classes and covariate estimates.

The model specification symbols i, s, q and k mean intercept, linear, quadratic and cubic slope, respectively.

The i and s symbols were specified as random effects (individually varying effects around a mean effect) and q and k as fixed average regression coefficients in the LGMM.

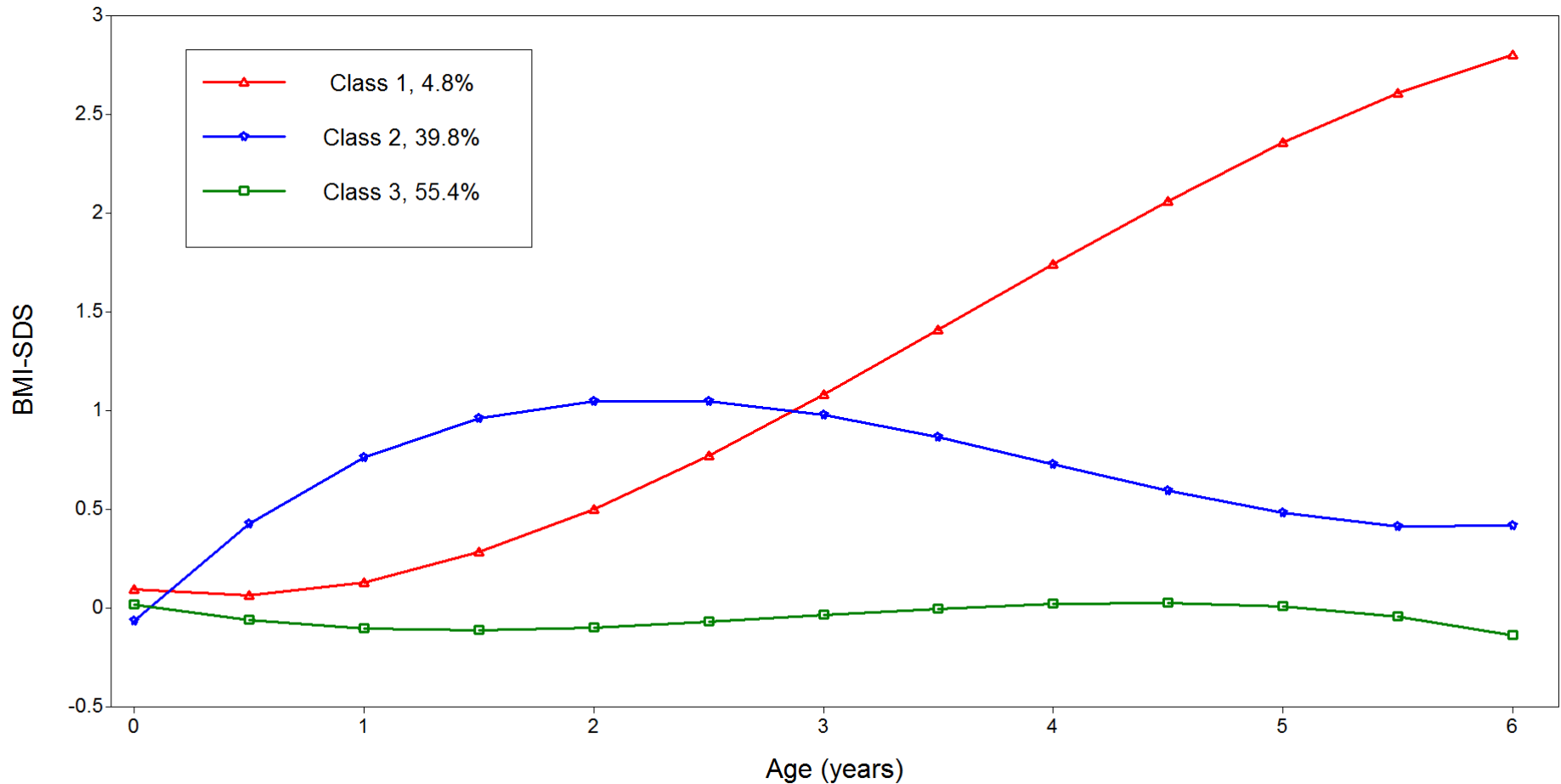
Formally the 4-class model has the best fit according to criteria like BIC, LMR-test and classification measure entropy.

However, the 4<sup>th</sup> class of the BMI-SDS growth pattern comprises only 0.4 % of the classified infants and its course looks quite artificial.

A 5-class model had the same problem and its LMR-test revealed that a 5 class model was not necessary.

Therefore, **the more parsimonious and more plausible 3-class model was selected**

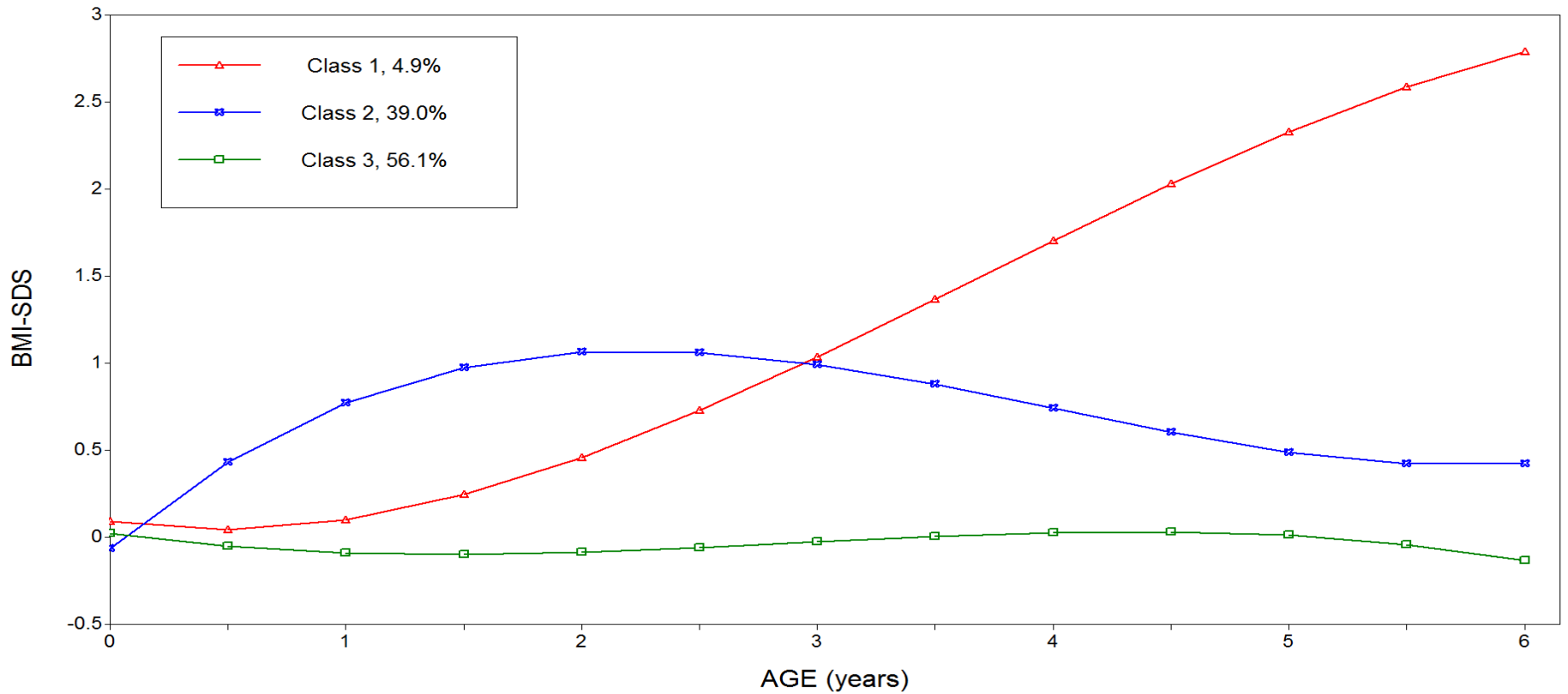
# Identified BMI-SDS trajectory classes from birth to 6 yrs (RAINE, CHOP, HUMIS, PreventCD pooled) – 3-step LGMM



**Figure 1. BMI-SDS derived growth pattern classes for the four pooled cohorts identified by longitudinal growth mixture modeling ( $n = 6708$ ). **Class 1** : Persistent, accelerating rapid growth; **Class 2**: Early, non-persistent rapid growth; **Class 3**: Normative growth.**

Association of breastfeeding with BMI-SDS growth pattern classes for the pooled cohorts \* Fully breastfed for

		all cohorts			
		Model 1		Model 2	
<b>Class 1</b>		OR	95%-CI	OR	95%-CI
<b>Fully breastfed*</b>					
<3 months		<b>4.54</b>	2.82 - 7.33	<b>2.75</b>	1.53 - 4.95
3+ months		1	-	1	-
Gestational age (weeks)		0.91	0.83 - 1.00	0.92	0.82 - 1.03
Maternal age at delivery (years)		-	-	1.00	0.96 - 1.04
Maternal pre-pregnancy BMI (kg/m <sup>2</sup> )		-	-	<b>1.13</b>	1.07 - 1.18
Maternal Education (yrs of schooling)					
<12 years		-	-	<b>3.20</b>	1.65 - 6.19
12+ years				1	-
Maternal smoking during pregnancy					
yes		-	-	<b>1.77</b>	1.07 - 2.93
no				1	-
<b>Class 2</b>					
<b>Fully breastfed*</b>					
<3 months		<b>1.85</b>	1.50 - 2.28	<b>1.97</b>	1.52 - 2.55
3+ months		1	-	1	-
Gestational age (weeks)		<b>0.80</b>	0.76 - 0.85	<b>0.81</b>	0.76 - 0.87
Maternal age at delivery (years)		-	-	0.99	0.97 - 1.01
Maternal pre-pregnancy BMI (kg/m <sup>2</sup> )		-	-	<b>1.05</b>	1.01 - 1.08
Maternal Education (yrs of schooling)					
<12 years		-	-	0.88	0.67 - 1.15
12+ years				1	-
Maternal smoking during pregnancy					
yes		-	-	<b>1.42</b>	1.07 - 1.87
no				1	-
<b>Class 3 (ref.)</b>		1	-	1	-



Effect of maternal BMI before pregnancy

**Class 1:** OR 1.13 (95% CI 1.07– 1.18)

**Class 2:** OR 1.05 (95% CI 1.01– 1.08)

## Measures of body composition at age 6 and 20 years

	at age 6 years		at age 20 years	
	n	mean $\pm$ sd	n	mean $\pm$ sd
BMI (kg/m <sup>2</sup> )	1773	15.8 $\pm$ 1.8	1247	24.5 $\pm$ 5.1
BMI-SDS	1773	0.2 $\pm$ 1.1	-	-
Triceps (mm)	1529	10.1 $\pm$ 3.1	1255	17.4 $\pm$ 8.6
Triceps-SDS	1529	0.2 $\pm$ 0.9	1255	0.3 $\pm$ 0.9
Subscapular (mm)	1528	6.2 $\pm$ 2.7	1248	16.1 $\pm$ 7.9
Subscapular-SDS	1528	0.3 $\pm$ 0.9	1248	0.4 $\pm$ 0.8
Fat mass (kg)	616	4.8 $\pm$ 1.7	1144	22.2 $\pm$ 12.0
Fat mass index (kg/m <sup>2</sup> )	491	3.0 $\pm$ 0.7	1142	7.6 $\pm$ 4.3

**Note:** At age 6 years estimates for BMI, BMI-SDS are based on all 4 cohorts (RAINE, CHOP, HUMIS and PreventCD). Skinfolds were available only for RAINE and CHOP cohorts and fat mass and fat mass index only for the CHOP study. At age 20 years estimates are based only on the RAINE study.

# Measures of body composition at age six and 20 years and BMI-SDS growth pattern classes

Distal outcome	at age 6 years				at age 20 years			
	mean	s.e.	P-value		mean	s.e.	P-value	
			C# vs. C3	C# vs. C2			C# vs. C3	C# vs. C2
<b>Class 1</b>								
BMI (kg/m <sup>2</sup> )	20.45	0.24	<.0001	<.0001	32.86	1.63	<.0001	<.0001
BMI-SDS	2.68	0.11	<.0001	<.0001	-	-	-	-
Triceps (mm)	17.42	0.53	<.0001	<.0001	24.64	2.50	0.002	0.008
Triceps-SDS	1.97	0.11	<.0001	<.0001	1.32	0.21	<.0001	<.0001
Subscapular (mm)	13.52	0.49	<.0001	<.0001	26.01	2.23	<.0001	<.0001
Subscapular-SDS	2.37	0.10	<.0001	<.0001	1.47	0.18	<.0001	<.0001
Fat mass (kg)	8.70	0.29	<.0001	<.0001	33.50	3.98	0.001	0.016
Fat mass index (kg/m <sup>2</sup> )	4.55	0.14	<.0001	<.0001	11.33	1.54	0.007	0.040
<b>Class 2</b>								
BMI (kg/m <sup>2</sup> )	16.46	0.06	<.0001	-	25.92	0.35	<.0001	-
BMI-SDS	0.68	0.04	<.0001	-	-	-	-	-
Triceps (mm)	11.10	0.19	<.0001	-	17.77	0.59	0.202	-
Triceps-SDS	0.53	0.05	<.0001	-	0.46	0.06	0.003	-
Subscapular (mm)	6.69	0.08	<.0001	-	17.06	0.55	0.003	-
Subscapular-SDS	0.58	0.05	<.0001	-	0.54	0.05	<.0001	-
Fat mass (kg)	4.99	0.08	<.0001	-	23.55	0.87	0.023	-
Fat mass index (kg/m <sup>2</sup> )	3.12	0.05	<.0001	-	8.05	0.32	0.037	-
<b>Class 3 (ref.)</b>								
BMI (kg/m <sup>2</sup> )	14.84	0.04	-	<.0001	22.37	0.32	-	<.0001
BMI-SDS	-0.35	0.03	-	<.0001	-	-	-	-
Triceps (mm)	7.93	0.20	-	<.0001	16.52	0.52	-	0.202
Triceps-SDS	-0.44	0.06	-	<.0001	0.16	0.06	-	0.003
Subscapular (mm)	4.90	0.04	-	<.0001	14.41	0.47	-	0.003
Subscapular-SDS	-0.42	0.06	-	<.0001	0.21	0.05	-	<.0001
Fat mass (kg)	3.89	0.05	-	<.0001	20.31	0.75	-	0.023
Fat mass index (kg/m <sup>2</sup> )	2.60	0.03	-	<.0001	6.98	0.27	-	0.037

**Note:** Means are estimated by the modified BCH 3 step procedure for LGMM with distal outcomes described in<sup>20</sup> and implemented in Mplus with the BCH option for the distal outcome. Essentially the respective distal outcome is used as outcomes in an ANOVA with growth pattern class as the factor. However, the estimates are classification error corrected (details see methods section). P-values are from equality tests of means across classes (class # vs. class C3 or C2 respectively). Of note: At age 6 years estimates for BMI, BMI-SDS are based on all 4 cohorts (RAINE, CHOP, HUMIS and PreventCD). Skinfolds were available only for RAINE and CHOP cohorts and fat mass and fat mass index only for the CHOP study. At age 20 years estimates are based only on the RAINE study.

# Measures of body composition at age six and 20 years and BMI-SDS growth pattern classes

Distal outcome	at age 6 years				at age 20 years			
	mean	s.e.	P-value		mean	s.e.	P-value	
			C# vs. C3	C# vs. C2			C# vs. C3	C# vs. C2
<b>Class 1</b>								
BMI (kg/m <sup>2</sup> )	20.45	0.24	<.0001	<.0001	32.86	1.63	<.0001	<.0001
BMI-SDS	2.68	0.11	<.0001	<.0001	-	-	-	-
Triceps (mm)	17.42	0.53	<.0001	<.0001	24.64	2.50	0.002	0.008
Triceps-SDS	1.97	0.11	<.0001	<.0001	1.32	0.21	<.0001	<.0001
Subscapular (mm)	13.52	0.49	<.0001	<.0001	26.01	2.23	<.0001	<.0001
Subscapular-SDS	2.37	0.10	<.0001	<.0001	1.47	0.18	<.0001	<.0001
Fat mass (kg)	8.70	0.29	<.0001	<.0001	33.50	3.98	0.001	0.016
Fat mass index (kg/m <sup>2</sup> )	4.55	0.14	<.0001	<.0001	11.33	1.54	0.007	0.040
<b>Class 2</b>								
BMI (kg/m <sup>2</sup> )	16.46	0.06	<.0001	-	25.92	0.35	<.0001	-
BMI-SDS	0.68	0.04	<.0001	-	-	-	-	-
Triceps (mm)	11.10	0.19	<.0001	-	17.77	0.59	0.202	-
Triceps-SDS	0.53	0.05	<.0001	-	0.46	0.06	0.003	-
Subscapular (mm)	6.69	0.08	<.0001	-	17.06	0.55	0.003	-
Subscapular-SDS	0.58	0.05	<.0001	-	0.54	0.05	<.0001	-
Fat mass (kg)	4.99	0.08	<.0001	-	23.55	0.87	0.023	-
Fat mass index (kg/m <sup>2</sup> )	3.12	0.05	<.0001	-	8.05	0.32	0.037	-
<b>Class 3 (ref.)</b>								
BMI (kg/m <sup>2</sup> )	14.84	0.04	-	<.0001	22.37	0.32	-	<.0001
BMI-SDS	-0.35	0.03	-	<.0001	-	-	-	-
Triceps (mm)	7.93	0.20	-	<.0001	16.52	0.52	-	0.202
Triceps-SDS	-0.44	0.06	-	<.0001	0.16	0.06	-	0.003
Subscapular (mm)	4.90	0.04	-	<.0001	14.41	0.47	-	0.003
Subscapular-SDS	-0.42	0.06	-	<.0001	0.21	0.05	-	<.0001
Fat mass (kg)	3.89	0.05	-	<.0001	20.31	0.75	-	0.023
Fat mass index (kg/m <sup>2</sup> )	2.60	0.03	-	<.0001	6.98	0.27	-	0.037

**Note:** Means are estimated by the modified BCH 3 step procedure for LGMM with distal outcomes described in<sup>20</sup> and implemented in Mplus with the BCH option for the distal outcome. Essentially the respective distal outcome is used as outcomes in an ANOVA with growth pattern class as the factor. However, the estimates are classification error corrected (details see methods section). P-values are from equality tests of means across classes (class # vs. class C3 or C2 respectively). Of note: At age 6 years estimates for BMI, BMI-SDS are based on all 4 cohorts (RAINE, CHOP, HUMIS and PreventCD). Skinfolds were available only for RAINE and CHOP cohorts and fat mass and fat mass index only for the CHOP study. At age 20 years estimates are based only on the RAINE study.

# Summary of findings

1) **Three types of BMI-SDS growth pattern were identified by LGMM;**

<b>Class 1:</b> Persistent, accelerating rapid growth	<b>(5%)</b>
<b>Class 2:</b> <i>Early, non-persistent rapid growth</i>	<b>(39%)</b>
<b>Class 3:</b> <i>Normative growth</i>	<b>(56%)</b>

2) **A higher maternal BMI before pregnancy increased the odds of children developing rapid BMI-SDS growth pattern (class 1 or class 2) rather than a normative growth pattern (class 3)**

The respective OR were **1.13** and **1.05** for each increment of maternal BMI even after adjustment for known covariates affecting BMI (gestational age, breastfeeding, education, smoking in pregnancy)



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## 2) A higher maternal BMI before pregnancy increased the odds of children developing rapid BMI-SDS growth pattern (**class 1** or **class 2**) rather than a normative growth pattern (**class 3**)

The respective OR were **1.13** and **1.05** for each BMI increment even after adjustment for known covariates affecting BMI (gestational age, breastfeeding, education, smoking in pregnancy)

## 3) Rapid growth trajectories (**class 1** or **class 2**) of children in the first 6 years of life result in higher BMI , larger skinfolds (Triceps, Subscapular) and increased fat mass in mid childhood (age 6 y) compared to those in the normative group (**class 3**) and among all groups in a dose response manner.

## 4) These differences tracked into adulthood (age 20 y).

# Conclusions

**The early postnatal period is an important time for obesity development of the offspring which may potentially be addressed through decreasing maternal weight before pregnancy**

**Too high a maternal BMI is a risk for obesity related rapid growth trajectories in the offspring and plays a mediating role in both short and long lasting effects on body composition.**

**As with other programming effects, the effect of maternal obesity before pregnancy on later obesity risk may amplify over time. Therefore the time before the pregnancy is a key to targeting interventions.**

**Our findings suggest that promoting loss of weight in young women before pregnancy may have long-term protective benefits against future obesity in children.**



**EARLYNUTRITION**

Thank you for your attention!