



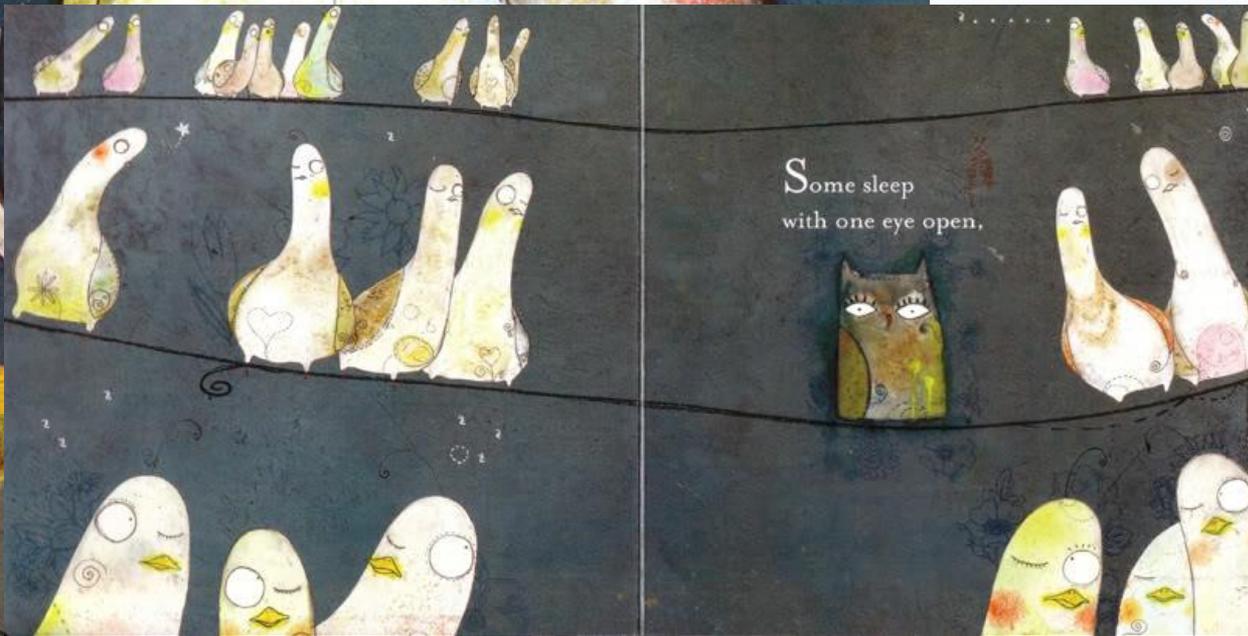
UNIVERSITY  
*of York*

**Understanding the  
downstream effects of  
preschool sleep for vocabulary,  
education and mental health  
outcomes in the ALSPAC and  
BiB longitudinal samples**

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Some make lots of noise  
when they sleep.



Some sleep  
with one eye open.

Some sleep  
in peace and quiet,

# Sleep in the early years

- Sleep in the early years is a dynamic process characterised by a period of transition in which daytime sleep reduces and sleep gradually consolidates into nighttime sleep;



- Some evidence suggests that sleep difficulties may persist throughout childhood and adolescence (Gregory & O'Connor, 2002);
- ~10-29% of infants and children under five years of age have difficulties with sleep (Byars et al., 2013; Williamson et al., 2019; Zuckerman et al. 1987);

# Sleep, mental health and development

- **Academic achievement**

- Poor sleep is associated with poorer academic performance (Hoyaniak et al., 2020; Stormark et al., 2019)

- **Mental health**

- Children with sleep problems have been found to have increased odds of having elevated symptoms of anxiety, emotional disorders, aggressive behaviour and irritability;
- Improving sleep quality leads to better mental health (Scott et al., 2021) in adults;

- **Language**

- Sleep positively correlates with language abilities

# Sleep, mental health and development: multiple routes

Direct route:

- Role of sleep in brain development, e.g., frontal lobe (Bernier et al., 2013; Nelson, Nelson, Kidwell, James, & Espy, 2015; Sadeh, 2007);
- Sleep influences offline consolidation, supporting the learning and retention of new words (Complementary learning system);
- Sleep loss often results in irritability, a short attention span, difficulty in modulating impulses and emotions, and increased behavioral problems (Ednick et al., 2009; Scharf, Demmer, Silver, & Stein, 2013; Touchette et al., 2007);

Indirect route:

- Chronic sleep loss affects physical health by increasing the risk of obesity and associated diseases (Knutson, 2012; Leproult & Van Cauter, 2010);
- Sleep problems are negatively associated with social functioning (Foley & Weinraub, 2017);

# Limitations with existing studies

## 1. Most studies are concurrent or with limited follow-up

Most studies followed children until school entry only

## 2. Often fail to consider moderating factors

Despite evidence that the effect of sleep in later childhood is moderated by household income and maternal education<sup>10-12</sup>

## 3. Lack of real-world outcomes

Studies often focus on experimental outcomes

## Secondary data analysis is ideal to answer these research questions

### **Avon longitudinal study of parents and children**

- ~14,000 children born in 1991-1992
- Regular follow-ups
- Rich dataset: questionnaires for parents, children, teachers, and clinics, linked educational data
- Educational assessments used in ALSPAC are not used today → replication with Born in Bradford dataset

### **Born in Bradford**

- Following ~13,500 children born in 2007-2010
- Subset of parents completed questionnaires about sleep in infancy and toddler years (BiB1000; ~1700 children)
- Linked educational data

# Three work packages (WP):

## WP1

Are sleep patterns stable over development?

## WP2

Does early sleep have downstream effects on later cognitive, mental health, school readiness, and academic achievement outcomes?

## WP3

Working collaboratively with our project partners to generate non-academic impact and disseminate the findings widely

# Three work packages (WP):

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Are sleep patterns stable over development?

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# WP1: Are sleep patterns stable over development?

Our study aims to

- assess whether children's sleep patterns are stable (relative to their peers) over childhood and into adolescence and whether there are distinct sleep trajectories across development;

# WP1: Sleep variables

	18 months		30 months		3 years		4 years		5 years		6 years		9 years	
	1 (yes)	2 (no)	1 (yes)	2 (no)	1 (yes)	2 (no)	1 (yes)	2 (no)	1 (yes)	2 (no)	1 (yes)	2 (no)	1 (yes)	2 (no)
<b>sleep routine</b>	9444.00	1518.00	8995.00	1144.00	9084.00	792.00	8809.00	536.00	8137.00	417.00	7967.00	388.00	7786.00	276.00
	86.15	13.85	88.72	11.28	91.98	8.02	94.26	5.74	95.13	4.87	95.36	4.64	96.58	3.42
<b>refused going to bed</b>	8003.00	2864.00	5406.00	4712.00	5563.00	4353.00	5630.00	3711.00	5307.00	3237.00	4061.00	4315.00	5326.00	2708.00
	73.64	26.36	53.43	46.57	56.10	43.90	60.27	39.73	62.11	37.89	48.48	51.52	66.29	33.71
<b>woken up early</b>	5746.00	5117.00	4217.00	5883.00	4474.00	5442.00	4600.00	4734.00	4616.00	3889.00	3901.00	4440.00	5072.00	2926.00
	52.90	47.10	41.75	58.25	45.12	54.88	49.28	50.72	54.27	45.73	46.77	53.23	63.42	36.58
<b>difficulty going to bed</b>	7435.00	3406.00	6024.00	4010.00	6218.00	3698.00	5575.00	3741.00	4580.00	3934.00	3087.00	5263.00	3813.00	4193.00
	68.58	31.42	60.04	39.96	62.71	37.29	59.84	40.16	53.79	46.21	36.97	63.03	47.63	52.37
<b>got up after being put to bed</b>	8182.00	2607.00	5625.00	4425.00	6659.00	3257.00	6082.00	3219.00	5747.00	2747.00	5102.00	3238.00	6210.00	1782.00
	75.84	24.16	55.97	44.03	67.15	32.85	65.39	34.61	67.66	32.34	61.18	38.82	77.70	22.30
<b>got up after little sleep</b>	8502.00	2331.00	7790.00	2277.00	8199.00	1717.00	8148.00	1140.00	7552.00	948.00	7297.00	1027.00	7458.00	524.00
	78.48	21.52	77.38	22.62	82.68	17.32	87.73	12.27	88.85	11.15	87.66	12.34	93.44	6.56

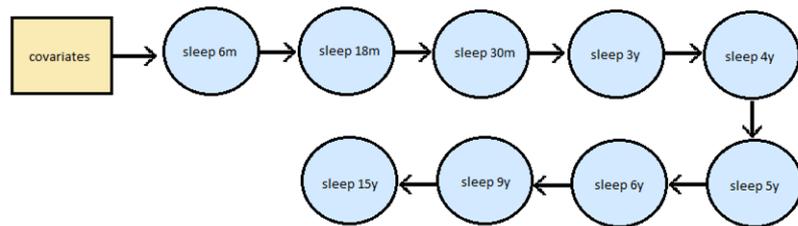
# WP1: Sleep variables

Age	Number of night awakenings			
	0 (never)	1 (once)	2 (2--3)	3 (>3)
18m	5427	3242	1799	290
	50.45	30.14	16.72	2.70
30m	5028	3346	1499	183
	50.00	33.27	14.91	1.82
3y	5495	3287	953	91
	55.92	33.45	9.70	0.93
4y	6429	2253	510	48
	69.58	24.38	5.52	0.52
5y	6477	1545	261	35
	77.87	18.57	3.14	0.42
6y	6817	1167	185	21
	83.24	14.25	2.26	0.26
9y	6637	879	136	19
	86.52	11.46	1.77	0.25

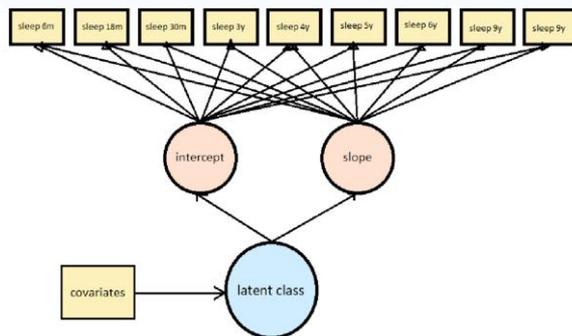
	Age	N	Mean	SD	Median
bedtime	18m	10825	19.78	0.95	19.50
	30m	10029	19.83	0.95	19.50
	3y	9811	19.77	0.85	19.50
	4y	9290	19.74	0.72	19.50
	5y	8412	19.87	0.70	20.00
	6y	8149	20.06	0.67	20.00
wakeup time	9y	8074	20.85	0.63	21.00
	18m	10898	7.10	0.84	7.00
	30m	10062	7.07	0.76	7.00
	3y	9863	7.03	0.70	7.00
	4y	9314	7.14	0.56	7.00
	5y	8466	7.16	0.51	7.00
	6y	8232	7.20	0.49	7.17
9y	8087	7.30	0.43	7.33	

# WP1: Data analysis

1. Exploratory factor analysis on each time point
2. Confirmatory factor analysis/Exploratory structural equation model on each time point
3. Cross-lagged panel model



4. Growth mixture model



# 1. Exploratory factor analysis

Scree plots suggest that 2-factor solution is the best fitting model across time points

One factor solution:

Variable	1.5y (18m)	2.5y (30m)	3y	4y	5y	6y	9y
sleep routine	.521*	.666*	.661*	.596*	.574*	.466*	.589*
refused going to bed	.794*	.796*	.756*	.802*	.760*	.657*	.641*
woken up early	.599*	.485*	.451*	.426*	.393*	.436*	.465*
difficulty going to bed	.810*	.764*	.719*	.781*	.719*	.641*	.688*
got up after being put to bed	.797*	.761*	.338*	.785*	.809*	.741*	.759*
got up after little sleep	.796*	.721*	.751*	.720*	.682*	.636*	.831*
night awakenings	.554*	.479*	.476*	.410*	.458*	.464*	.542*
bedtime	.309*	.312*	.306*	.271*	.249*	.190*	.184*
wake up time	.009	.056*	.087*	.133*	.113*	.072*	.114*

# 1. Exploratory factor analysis

Two factor solution:

Variable	1.5y (18m)		2.5y (30m)		3y		4y		5y		6y		9y	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
<b>sleep routine</b>	.435*	.386*	.420*	.513*	.369*	.578*	.473*	.392*	.451*	.483*	.415*	.328*	.458*	.412*
<b>refused going to bed</b>	.771*	.100*	.722*	.161*	.642*	.219*	.790*	.029	.749*	.029	.652*	-.001	.611*	.094
<b>woken up early</b>	.715*	-.391*	.691*	-.346*	.709*	-.384*	.585*	-.453*	.558*	-.535*	.553*	-.452*	.637*	-.374*
<b>difficulty going to bed</b>	.801*	.024	.726*	.088*	.686*	.065	.777*	.001	.714*	0	.626*	.054	.658*	.085
<b>got up after being put to bed</b>	.793*	.003	.777*	-.013	.434*	-.158*	.777*	.011	.785*	.076*	.719*	.098*	.697*	.183*
<b>got up after little sleep</b>	.808*	-.068*	.732*	-.004	.764*	-.004	.781*	-.197*	.767*	-.308*	.656*	-.117*	.846*	-.026
<b>night awakenings</b>	.562*	-.045	.451*	.063*	.466*	.022	.440*	-.104*	.489*	-.128*	.480*	-.100*	.550*	-.018
<b>bedtime</b>	.210*	.579*	.005*	.693*	.008	.657*	.144*	.564*	.152*	.522*	.148*	.399*	.038	.484*
<b>wake up time</b>	-.092	.436*	-.137*	.394*	-.130*	.417*	-.001	.557*	.004	.522*	.002	.552*	-.018	.411*

# 1. Exploratory factor analysis

Two factor solution:

Variable	1.5y (18m)		2.5y (30m)		3y		4y		5y		6y		9y	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
sleep routine	.435*	.386*	.420*	.513*	.369*	.578*	.473*	.392*	.451*	.483*	.415*	.328*	.458*	.412*
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Factor 1 seems to reflect **sleep quality**

# 1. Exploratory factor analysis

Two factor solution:

Variable	1.5y (18m)		2.5y (30m)		3y		4y		5y		6y		9y	
Factors	1	2	1	2	1	2	1	2	1	2	1	2	1	2
sleep routine	.435*	.386*	.420*	.513*	.369*	.578*	.473*	.392*	.451*	.483*	.415*	.328*	.458*	.412*
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Factor 2 thought to reflect **sleep routine**

## 2. Exploratory structural equation model

- Exploratory factor analysis for each data point was validated in the second half of the dataset
- Based on the scree plot and the high number of cross-loadings the following models were fitted and compared:
  - One-factor confirmatory factor analysis;
  - Classic two-factor confirmatory factor analysis;
  - Two-factor confirmatory factor analysis allowing cross-loadings for items with cross-loadings  $>.30$ ;
  - Two-factor exploratory structural equation model – allows all items to load on all factors as in EFA;

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  - Two-factor exploratory structural equation model – allows all items to load on all factors as in EFA;

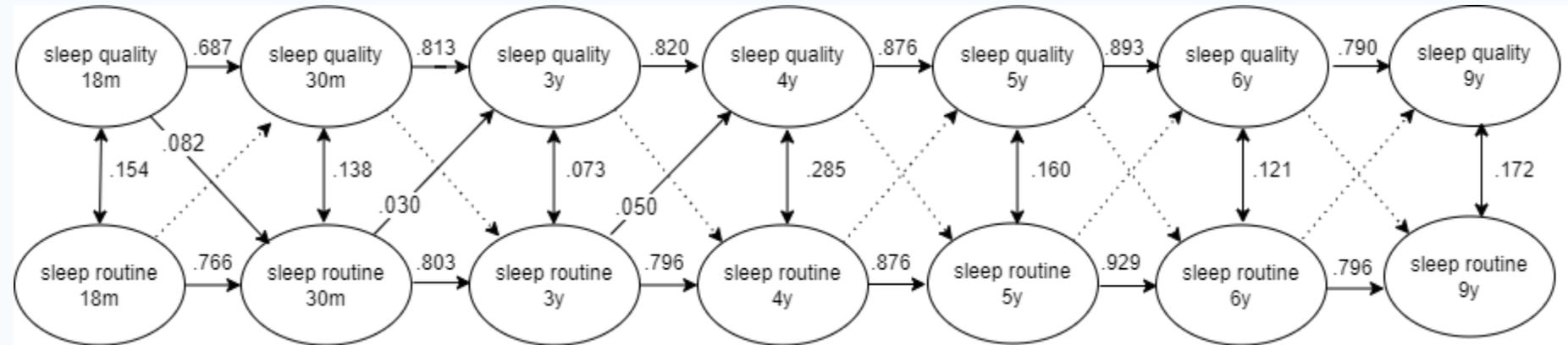
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## 2. Exploratory structural equation model

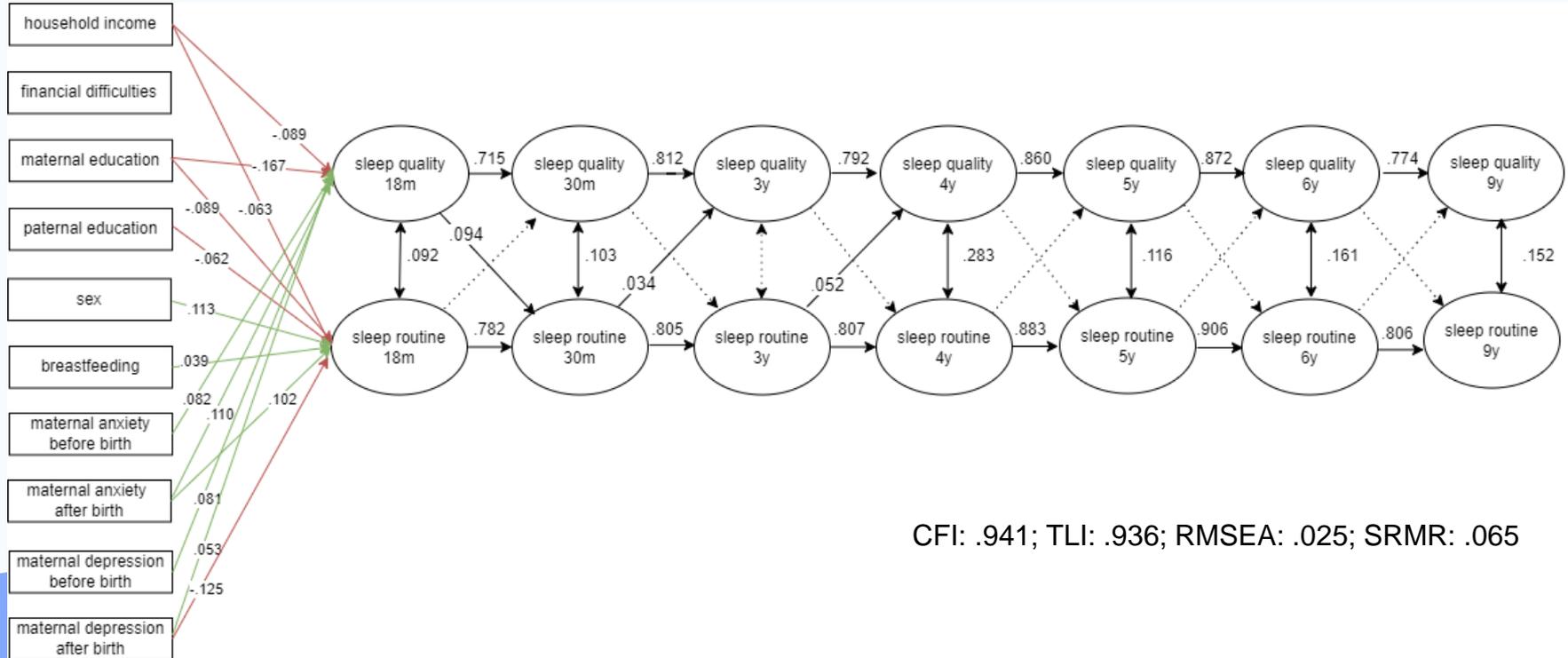
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  - **Two-factor exploratory structure equation model – allowing all items to load on all factors as in EFA:**
    - **Factor 1 - Sleep quality;**
    - **Factor 2 - Sleep routine;**

### 3. Cross-lagged panel model



CFI: .937; TLI: .930; RMSEA: .028; SRMR: .059

### 3. Cross-lagged panel model with covariates

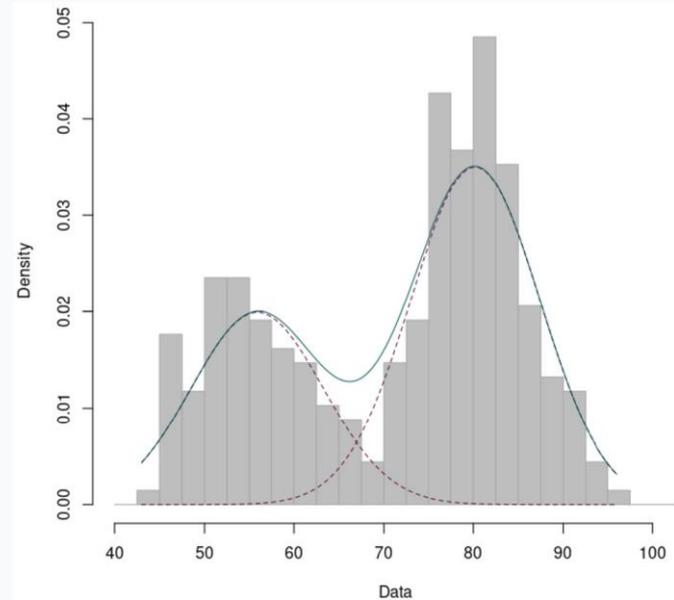


CFI: .941; TLI: .936; RMSEA: .025; SRMR: .065

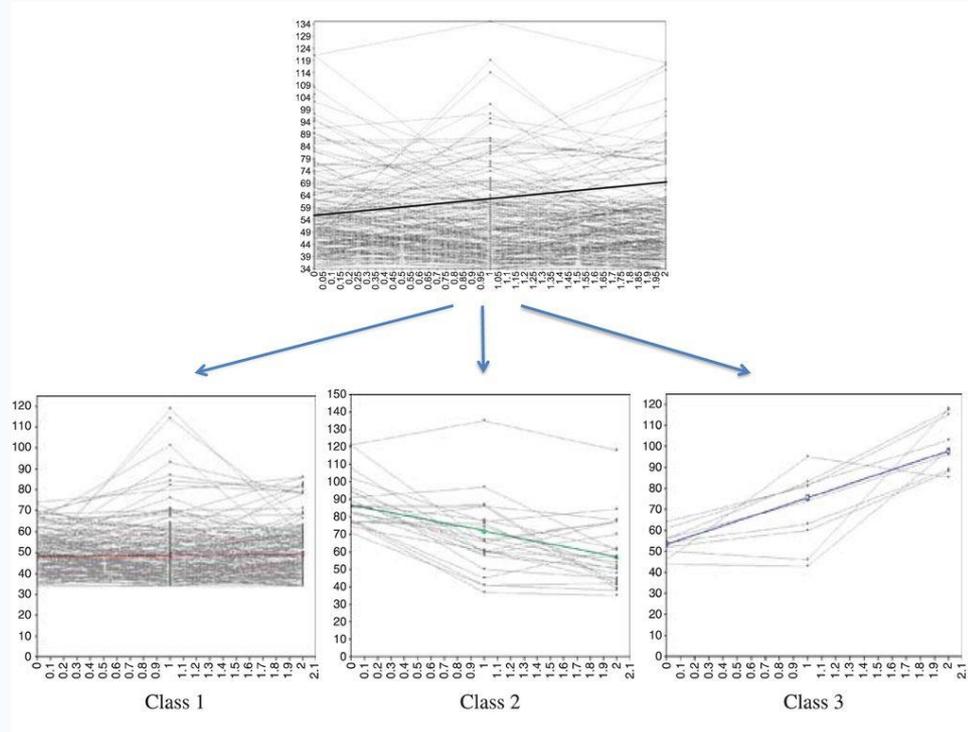
# 4. Growth mixture model

Allows the

- identification of multiple unobserved sub-populations;
- description of longitudinal change within each unobserved sub-population;
- examination of differences in change among unobserved sub-populations;



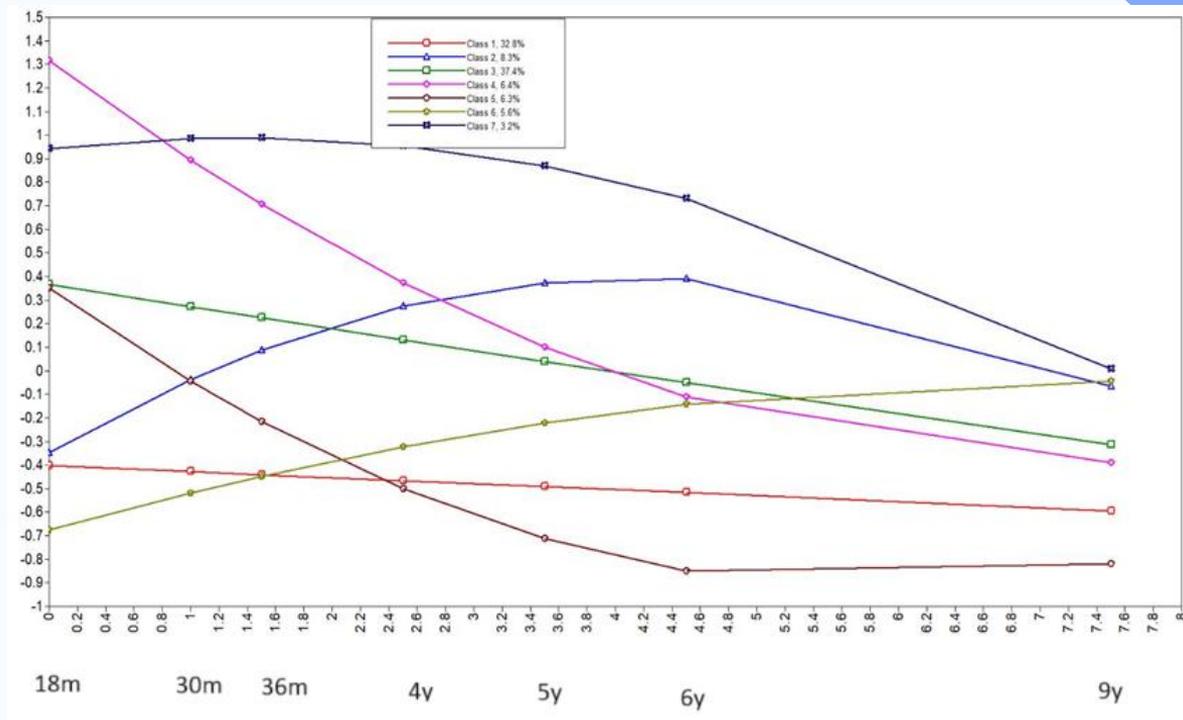
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# 4. Growth mixture model: Sleep quality

7 distinct sleep quality trajectories:

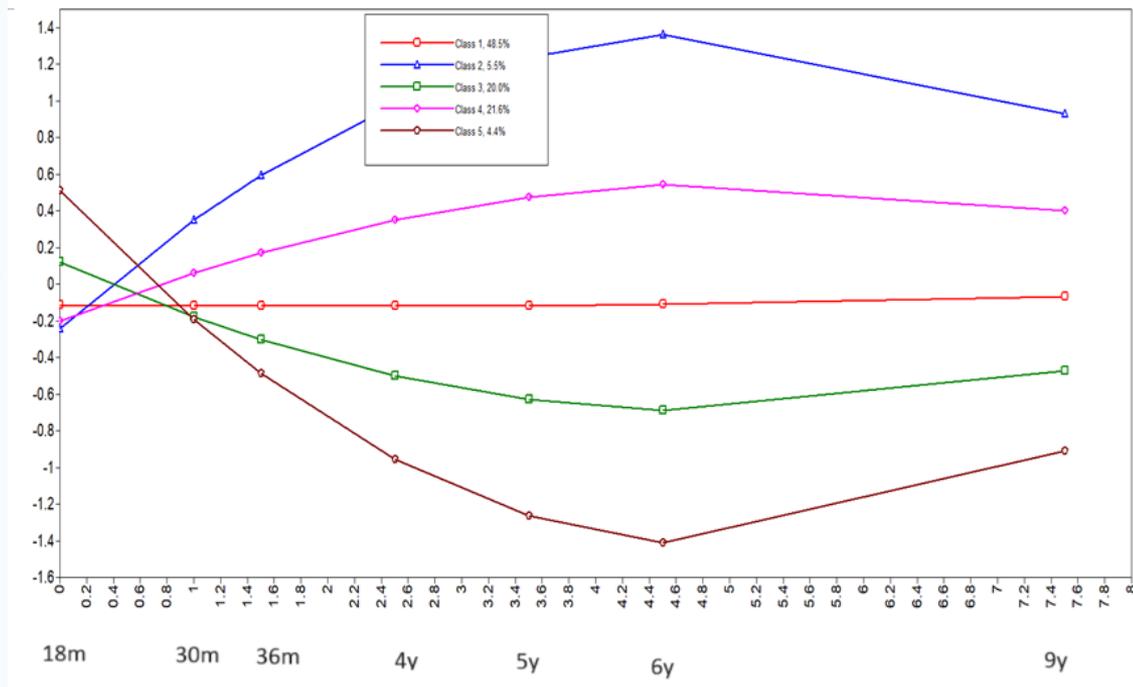
- 5/7 sleep quality trajectories demonstrate improvements across development;
- A significant minority of children show persistent sleep quality problems or worsening sleep across time;



# 4. Growth mixture model: Sleep routine

5 distinct sleep routine trajectories:

- There is limited variability in the intercept of the trajectories;
- The majority of children show a consistent sleep routine trajectory or with limited variation in sleep routine across time;
- ~10% show considerable change in their sleep routine across development (4.4% showing considerably early sleep timings, whilst 5.5% show the opposite pattern);



# Conclusions

- Children's sleep across development is fairly stable when compared to their peers, particularly when pertaining to sleep routine; this may be in part related to school attendance;
- There seems to be a trend for an improvement of sleep quality across development, but a substantial minority of children for whom sleep is getting worse or staying worse over time;
- In line with previous studies, only a small number of children showed persistent sleep problems;
- Identifying predictors of the sleep trajectories membership will allow the identification of child and parent risk factors for sleep problems which may be helpful for prevention and intervention;
- Future work (WP2) will determine how these sleep trajectories influence vocabulary, school readiness, academic achievement, and mental health;

**Note:** results are preliminary.

# Acknowledgements

