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1 FRENCH VALIDATION OF THE SLEEP DISTURBANCE SCALE FOR CHILDREN (SDSC) IN  
2 YOUNG CHILDREN (aged 6 months to 4 years)

3

4 Florian Lecuelle<sup>a</sup>, Marie-Paule Gustin<sup>b,c</sup>, Wendy Leslie<sup>a</sup>, Jodi A. Mindell<sup>d,e</sup>, Patricia Franco<sup>a,f</sup>,  
5 Benjamin Putois<sup>a,f,g</sup>

6

7 Affiliations:

8 a. Pediatric Sleep Unit, Hospital for Women Mothers & Children, Lyon 1 University, France.

9 b. Institute of Pharmaceutic and Biological Sciences, University Claude Bernard Lyon 1,  
10 Villeurbanne, France.

11 c. Emerging Pathogens Laboratory–Fondation Mérieux, International Center for Infectiology Research  
12 (CIRI), Inserm U1111, CNRS UMR5308, ENS de Lyon, Lyon, France.

13 d. Children’s Hospital of Philadelphia, Philadelphia, PA.

14 e. Saint Joseph’s University, Philadelphia, PA.

15 f. Research Laboratory on the Physiology of the Brain Arousal System, CRNL, INSERM-U1028,  
16 CNRS UMR5292, Lyon, France.

17 g. Swiss Distance Learning University, Sierre, Switzerland.

18

19 Corresponding author:

20 Benjamin Putois, Ph.D

21 Swiss Distance Learning University, Study Centre of Sierre, Technopôle 5, 3960 Sierre, Switzerland.

22 email: benjamin.putois@unidistance.ch

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26 **Abstract**

27 The sleep disturbance scale for children (SDSC) has been translated and adapted into several  
28 languages and its psychometric properties are good. Notably, a French version has been validated for  
29 4- to 16-year olds. The objective of the current study was therefore to adapt and validate the SDSC for  
30 French young children (aged 6 months to 4 years).

31 *Method:* 421 French-speaking mothers of children aged between 6 months to 4 years completed the  
32 SDSC and the Brief Infant Sleep Questionnaire (BISQ) which is specifically for young children. Of  
33 these, 105 children were diagnosed with sleep disorders (clinical group) during a sleep consultation,  
34 and 316 completed the SDSC and BISQ in a network of nurseries (control group). Several factor  
35 analyses were conducted to identify the most consistent factor structure for this sample.

36 *Results:* Three items from the previous version were deleted due to lack of clinical relevance for this  
37 age group. The best factor analysis revealed 6 factors, comparable to the Italian version of the SDSC  
38 for children: Disorders of Initiating Sleep, Disorders of Maintaining Sleep, Sleep Hyperhidrosis, Sleep  
39 Breathing Disorders, Parasomnias, and Non-Restorative Sleep and Excessive Somnolence. This  
40 psychometric structure is reliable and aligned with expert diagnoses. The convergent validity, and  
41 divergent and internal reliability were acceptable.

42 *Conclusion:* This study validates a 22-item SDSC for French young children. Coupled with some  
43 questions from the BISQ, the SDSC could therefore be used to facilitate the detection of sleep  
44 disturbances in children aged between 6 months and 4 years old.

45 *Keywords:*

46 Sleep; Children; Questionnaire; French version; Sleep Disturbance Scale for Children; Young  
47 children;

48  
49 **Highlights**

- 50
- The Sleep Disturbance Scale for Children is available for young French children (6 months to  
51 4 years)
  - This 22-item version has good psychometric properties, with a total score cut-off of 37.
  - The SDSC for French young children should be used in conjunction with the Sleep Hygiene  
53 Scale for Children.  
54

55 **1. Introduction**

56 Sleep disturbances are a major cause for pediatric consultation. These are most common during the  
57 first 5 years of life [1]. Indeed, the prevalence of sleep-related disturbances is estimated to be between  
58 35% and 46%[2]. In young children, child sleep disturbances perturb the whole family, increasing  
59 marital conflicts and the risk of depression in parents [3]. Sleep disorders which are not treated early  
60 will tend to persist over time [4]. Treatment is complex, as there are many kinds of sleep disorders and  
61 etiologies [5]. Diagnosis requires consideration of a combination of medical and psychological  
62 information about the child, concerning organic, developmental, psychological, behavioral and dietary  
63 aspects. As such, questionnaires are a highly useful tool for clinical practice.

64 The Sleep Disturbance Scale for Children (SDSC) was initially developed for children between the  
65 ages of 6 and 15 years old [6]. It comprises questions concerning their sleep over the previous 6  
66 months and is hetero-assessed by their parents on a 5-point Likert scale. It is free and the time required  
67 for completion to complete it is approximately 10 minutes. The SDSC has the best psychometric  
68 properties (high internal consistency of 0.79 among control subjects and 0.71 among clinical subjects)  
69 [7]. It has been validated in several languages: Portuguese [8], Chinese [9], Flemish [10], French [11],  
70 and Australian [12]. It was also validated among an Italian population of 3 to 6 year olds [13]. The  
71 French version was only validated among 4 to 16-year olds. To enable diagnosis and therapy for sleep  
72 disturbances at an earlier age, the French questionnaire thus needed to be adapted to a population of  
73 children (6 months to 4 years old). Characteristics of sleep (nocturnal sleep duration, number of night  
74 awakenings...) that are modified in case of sleep disorders have been shown to be correlated with  
75 several factors together called "Sleep Hygiene" [14] which are relevant for younger children:  
76 nighttime feeding [15], television, computer or mobile device use [16,17], sleep rituals [18], and  
77 parental behaviors [19]. International recommendations stipulate the appropriate behaviors to adopt  
78 regarding nighttime awakenings [20]. The risk of sudden infant death should also be systematically  
79 assessed, particularly regarding the child's position when they sleep and the practice of co-sleeping  
80 [21]. Some aspects of this sleep hygiene can be collected using part of the Brief Infant Sleep  
81 Questionnaire (BISQ) [22,23] and questions about the child's exposure to screens [17].

82 The main objective of the present study was to validate a French version of the SDSC adapted for  
83 preschool (6 month-to-4-year-old) Children (SDSC-Y) by starting from the previous 25-item French  
84 version of the SDSC [11]. The construct validity of the SDSC-Y was assessed using exploratory  
85 (EFA) and confirmatory (CFA) factorial analyses, its reliability using standard Cronbach's alpha. The  
86 concurrent criterion validity was studied using validated aspects of sleep hygiene, assessed using the  
87 BISQ in the framework of a structural equation modelling (SEM). Discriminant validity between  
88 control and clinical groups was studied and a ROC analysis was performed to assess the diagnostic  
89 validity of the SDSC-Y.

## 90        **2. Method**

91        The present study is the second psychometric validation of the French SDSC and follows the study of  
92        4-16 years old by Putois et al. (2017). Both studies were approved by the Léon Bérard Committee for  
93        the Protection of Persons in Lyon (CPP). All the mothers who participated in the study signed a  
94        consent form. They completed both the SDSC and extended BISQ.

### 95                **2.1 Participants**

96        This study comprised two samples: a clinical group of children having sought consultations with the  
97        last-cited author of the present paper, and a control group of children attending partner nurseries.  
98        According to information provided by parents, all children with reported signs of mental,  
99        developmental or physical disabilities or receiving on-going prescription medication (antiepileptic  
100        drugs, antihistaminic drugs, benzodiazepine, melatonin) were excluded.

101        The clinical group comprised 105 children. The French versions of the SDSC [11] and BISQ were  
102        completed by the child's mother prior to the consultation. Diagnoses were made during a one-hour  
103        consultation with a qualified sleep specialist (the last-cited author) and established according to the  
104        criteria set out in the third edition of the International Classification of Sleep Disorders [20]. The  
105        consultation involved a clinical examination of the child, an interview with the mother and analysis of  
106        the sleep diary recorded over at least the 15 days preceding the consultation.

107        For the control group, the French version of the SDSC and BISQ questionnaires were sent to 780  
108        parents of children attending the partner nurseries involved in this study and were completed by the  
109        children's mother, as for the control group. These parents had never sought a consultation about their  
110        children's sleep. Of the 780 questionnaires sent, 321 were returned, i.e. a 41% response-rate. 5 were  
111        not correctly completed (missing age or gender) and were therefore excluded from the analyses. In  
112        total, 316 children were included in the control group.

### 113                **2.2 Elaboration of the SDSC-Y based on the SDSC**

114        A committee of experts (Benjamin Putois, Patricia Franco and Marie-Joseph Challamel) conferred and  
115        decided to remove the items regarding sleepwalking [24], bruxism [25,26] and narcolepsy-cataplexy  
116        [27] (items 15, 17 and 25 according to Putois and colleagues [11]), given their low prevalence for  
117        young children. This adaptation thus yielded a 22-item questionnaire (the age-adapted SDSC) (See  
118        Appendix A).  
119

### 120                **2.3 Elaboration of the Sleep Hygiene Scale for Children based on the BISQ**

121        The BISQ assesses aspects of a young child's day and night: sleep habits, sleeping position, co-  
122        sleeping, information relating to sudden infant death, breastfeeding, any sleeping rituals, sleep routines  
123        such as bedtime and parental behavior when their child goes to sleep or with nighttime awakenings.  
124        The translation was examined by the study's committee of experts. All BISQ items of the French  
125        version are deemed to be well understood. The BISQ contains no numerical scale, it is merely a  
126

127 descriptive questionnaire with yes-no questions. Two items about screen exposure were added [17]. In  
128 order to control the influencing factors of early childhood sleep disorders, only items correlated with  
129 the SDSC total score and respected international recommendations about appropriate behaviors to  
130 adopt regarding sleep hygiene [14] were selected for the statistical analysis. The derived version was  
131 named the Sleep Hygiene Scale for Children.

132

## 133 **2.4 Procedure and statistical analysis**

134 The results are presented in the form of mean  $\pm$  standard deviation for quantitative variables, and in  
135 the form of absolute frequency N, followed by the percentage observed (%) for qualitative variables.  
136 Normality of data was graphically assessed using the curve, and statistically using the Shapiro test.  
137 Simple comparisons between the two groups were carried out using the Student t-test or Wilcoxon  
138 rank-sum test, depending on the distribution. Pearson or Spearman correlations were carried out  
139 depending on the distribution of the sample.

140

### 141 **2.4.1 Item characteristics**

142 The mean and SD of item scores were reported with skewness and kurtosis to assess the non-normality  
143 of the item distribution.

144

### 145 **2.4.2 Construct validity**

146 An exploratory factor analysis was conducted by taking into account the ordinal nature of the item  
147 scores and using geomin rotation because subdimensions of the SDSC-Y were expected to be  
148 correlated as the whole scale measured global latent sleep disorders. Successive models with an  
149 increasing number of factors were fitted. A root mean square error of approximation (RMSEA)  $< 0.06$   
150 and comparative fit index (CFI) value  $> 0.95$  were considered representative of a factor analysis well-  
151 fitting for all [28]. Extra criteria could be considered in order to fine tune the model selection. The  
152 selected model must have all factors with eigenvalues above 1. An increase of 1% of the CFI between  
153 two successive models was considered as an improvement of the fit. When a model with a specified  
154 number of factors enables a plausible description of the data, the chi-square statistics would be  
155 expected to have the magnitude of associated degrees of freedom. After EFA, items were then affected  
156 to one factor according to their correlation ( $>0.30$ ) and their clinical meaning. Then, a confirmatory  
157 factor analysis was performed to validate the retained factor structure using robust weighed least  
158 squares [29].

159

### 160 **2.4.3 Items and Scale reliability**

161 Reliability of internal consistency of the scale and its subscales was assessed using Cronbach's alpha  
162 [30] which estimates the percentage of the total sum of scores variability explained by the underlying  
163 sleep propensity. This coefficient indicates an acceptable reliability when over 0.70 [31].The

164 contribution of each item to the reliability of the whole scale was studied i) by re-estimating the  
165 Cronbach's alpha after the deletion of each item in turn and ii) by examining relationships between  
166 scores of each item and the total score of the SDSC-Y. For the last point the corrected item-total score  
167 correlations were calculated (by excluding the corresponding item from the total SDSC-Y score).

168

#### 169 **2.4.3 Concurrent criterion validity**

170 The concurrent criterion validity was assessed using the 12-item Sleep Hygiene Scale for Children, the  
171 factor analysis of which was investigated as explained above for the SDSC-Y. The correlation  
172 between the latent dimension or subdimensions of the SDSC-Y and the latent sleep hygiene  
173 dimensions were estimated using structural equation modelling. Standardized coefficients were  
174 reported with their 95% confidence interval.

175

#### 176 **2.4.3 Discriminant and diagnostic validity**

177 Discriminant validity was calculated using the difference in mean between the control and clinical  
178 groups. First, scores were obtained for the control group (group of nursery children) using the formula  
179 used in other studies [13]  $\left(T - score = 50 + 10 \times \left(\frac{Value - mean}{Standard\ Deviation}\right)\right)$  and the usual pathological  
180 threshold was employed (T-score > 70 indicates a pathological score). Secondly, an analysis of the  
181 performance characteristics of the test (ROC) was carried out to identify the optimal threshold value  
182 using Youden criteria with the control group (nursery children) and the clinical group (children in  
183 sleep consultations). The values of sensitivity, specificity, area under the curve (AUC) and threshold  
184 for the total score were calculated. This ROC analysis was carried out for the whole total score of the  
185 SDSC-Y.

186

187 Standard statistical analyses were performed using R language "R version 3.5.2" available at  
188 <http://cran.r-project.org/> and Mplus 7.11 version 7.1 software available on the website  
189 <https://www.statmodel.com/> for factor analysis and SEM using robust weighed least squares due to the  
190 potential non-normality of item scores [32]. The R packages used were MplusAutomation [33], psy  
191 for Cronbach coefficient and pROC for ROC analysis. A significance threshold of 0.05 was chosen  
192 unless otherwise indicated.

193

194 **3. Results**

195 **3.1 Participants**

196 The mean age for the control group was 22 months with 60% boys (standard deviation = 11 months,  
197 N = 316) and for the clinical group, the mean age was 24 months with 47% boys (standard deviation =  
198 12 months, N = 105). In the clinical group, all 105 children received a diagnosis of insomnia, with 10  
199 presenting several comorbidities: three with an ear-nose-throat disorder, three with gastro-esophageal  
200 reflux, three with asthma and nine with sleep breathing disorders, and eight children presented two  
201 disorders simultaneously. In this same group, ten children no longer suffered from insomnia (in  
202 remission), but the parents still reported issues concerning their children's sleep.

203

204 **3.2. Item descriptions**

205 All items had left-tailed distribution with positive skewness coefficient (Supplementary Table 1, and  
206 Supplementary Figure 1, pages 2-6). Height items (1, 11, 12, 16, 17, 20, 21 and 22) had extreme  
207 skewness and kurtosis denoting a long-right tail and a fat left tail. No children slept less than 5 hours  
208 per night or had sleep attacks at least 3 times per week. More than 90% of the subjects scored the first  
209 response category for 3 items (12. Sleep apnea, 20. Sleep paralysis and 22. Sleep attacks) as if these  
210 items were little relevant to this population (fat left tail - high kurtosis). All items correlated  
211 significantly with the total score. We can note, however, that seven items had a low item-total  
212 correlation <0.30 (items: 11, 12, 13, 15, 18, 20, 22). These items, except for item 18, seemed to  
213 behave more like dichotomous or trichotomous items.

214

215 **3.3. Construct validity of the SDSC-Y**

216 The results of the EFA for the SDSC-Y are summarized in Table 1. Two models with all eigenvalues  
217 above 1 demonstrated acceptable fit: the 5-factor and 6-factor models explained 64% and 69% of the  
218 total variance respectively. CFI decreased more than 1% between both models and the ratio of Chi-  
219 square statistics on the degree of freedom was closer to 1 for the 6-factor model. With the 5-factor  
220 solution, 9 items (1, 7, 9-12, 14, 21-22) cross-loaded, while only two items (1, 6) cross-loaded with the  
221 6-factor solution (Table 2). The 6-factor model was therefore retained: factor 1 is Disorders of  
222 Initiating Sleep (DIS), factor 2 is Disorders of Maintaining Sleep (DMS), factor 3 is Sleep  
223 Hyperhidrosis (SHY), factor 4 is Sleep Breathing Disorders (SBD), factor 5 is Parasomnia (PARA),  
224 and factor 6 is Non-Restorative Sleep and Excessive Somnolence (NRSES). The first-order  
225 confirmatory factorial analysis model with 6 factors showed an acceptable fit (RMSEA= 0.053 <  
226 0.060; CFI = 0.958 > 0.90). As the two latent variables DIS and DMS were highly correlated with  
227 items having close meanings, it was supposed that these two latent variables DIS and DMS were  
228 explained by a latent variable DIMS. In addition, the overall sleep disorders were supposed to be  
229 explained by 5 latent variables (F12, F3, F4, F5 and F6) leading to a third-order confirmatory factorial  
230 model (RMSEA= 0.053 < 0.060; CFI = 0.958 > 0.90) presented in Figure 1.



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### **3.4 Scale reliability of the SDSC-Y**

The scale reliability was acceptable with a global Cronbach's alpha of 0.86.

### **3.5 Concurrent criterion validity of the SDSC-Y using the Sleep Hygiene Scale for Children**

Ten items of the BISQ and 2 items about screen exposure were correlated with the total SDSC score. This produced a 12-item questionnaire (the Sleep Hygiene Scale for Children, SHSC) (see Appendix B). The exploratory and confirmatory factorial analysis of the SHSC was reported in the Supplementary Data on pages 8-9. The 3-factor model was retained because it was the smallest model with acceptable fit ( $RMSEA = 0.055 < 0.06$ ;  $CFI = 0.939 > 0.90$ ) and it explained 66% of the total variance of the SHSC (Supplementary Table 2 and Table 3, page 8). The 3 cross-loading items (6, 10 and 12) were assigned to the factor with which they had the highest factor loading. The three factors were " Attachment parenting" (items 1 to 6, 8 and 10), " Transitional coping" (items 7 and 9) and "Screen exposure" (items 11 and 12). The confirmatory 3-factor model demonstrated a good fit ( $RMSEA = 0.048$ ,  $CFI=0.922$ ) (Supplementary Figure 2, page 9).

Two structural equation models including the 22 items of the SDSC-Y and the 12 items of the SHSC demonstrated acceptable fit. These estimated the pairwise correlations between the SHSC latent sub-dimensions and the latent global Sleep Disorders and its latent sub-dimensions (Supplementary Table 4, page 10). The highest correlations were obtained for "Attachment parenting" with global DIMS (.66) and SDSC-Y (.55) and between "Screen Exposure" and NRSES (.38), global SDSC-Y (.36) and DIMS (.32) (Figure 3). "Transitional coping" did not correlated significantly with the global SDSC-Y nor the subscore SDSC-Y.

### **3.6 Diagnostic validity of the SDSC**

#### **3.6.1 Distribution**

Distribution of the total score in the control group (ranging between 22 and 78) was asymmetric (Shapiro Wilk  $W = 0.91$ ,  $p < 10^{-12}$ ) and that of the clinical group (ranging between 22 and 75) was normal (Shapiro Wilk  $W = 0.99$ ,  $p = .85$ ). The control and clinical distributions are presented in Figure 2 for the total SDSC-Y score. The total T-score and sub-scores differed significantly between the clinical and control groups, across the five main subscales (F12, F1-F6) except for SHY and SBD (see supplementary Table 5, page 11 for details).

#### **3.6.2 Cut-off for the SDSC**

By applying the standard deviation formula on the control group for the pathological threshold (T score >70), the sub-scores obtained the following detection thresholds (See Appendix C): 16 for the DIMS factor (F12), 4 for SHY and 4 for SBD, 7 for PARA and 7 for NRSES.

268 The ROC analysis of data, taking the control and clinical groups as binary classifiers, demonstrated  
269 that the French SDSC for young children produces good diagnostic precision (AUC = 0.849). The  
270 detection threshold for the total score is determined by the best compromise between sensitivity (0.84)  
271 and specificity (0.74) and is set at 38. The detection threshold of 37 set by the pathological threshold  
272 (T score > 70) obtains a good compromise between sensitivity (0.86) and specificity (0.72). With this  
273 cut-off, the French version correctly detects 72% (227/316) for the control group and 86% (90/105)  
274 for the clinical group. The two cut-offs obtained are very close, so the cut-off of 37 seems appropriate  
275 for the age-adapted SDSC total score.

276

## 277 **4. Discussion**

### 278 **4.1 Statements of principal findings**

279 The aim of the present study was to apply the SDSC to a population of children aged between 6  
280 months and 4 years old. This study validated a modified version of the SDSC for young French  
281 children. This SDSC-Y consists of 22 items divided into five factors: DIMS, SHY, SBD, PARA and  
282 NRSES and is a good diagnostic tool to detect sleep disorders in the general population.

283

### 284 **4.2 Strengths and weaknesses of the study**

285 This study is the first to test the SDSC with children aged under 4 years old. The control group sample  
286 is large and representative of the general population of young children, as it includes children from  
287 different nurseries and diverse socio-economic contexts.

288 The psychometric properties of the SDSC are very satisfactory: Construct validity and scale reliability  
289 are good. The distribution of global scores for the control group and the clinical group is significantly  
290 different, even considering that certain children in the control group will have experienced sleep  
291 disturbances. It is interesting to note that the distributions of this study are comparable to those  
292 observed by Bruni et al., 1996 ; Romeo et al., 2013 and Putois et al., 2017 [6,11,13]. The cut-off for  
293 the SDSC adapted for children aged 6 months - 4 years old is 37 for the total score. Regarding the area  
294 under the curve (AUC = 0.849), the level of sensitivity (0.72) and of specificity (0.86) were obtained.  
295 The SDSC correctly detected 90 of 105 pathological sleep diagnoses in the clinical group. Given that  
296 10 of the children had insomnia in remission, the SDSC demonstrated good diagnostic precision. We  
297 can therefore conclude that the diagnostic validity is satisfactory especially for insomnia. Indeed, the  
298 major weakness of this study is the homogeneity of the clinical group (insomnia only) due to a  
299 selection bias (only consultation data provided by the last author, an insomnia specialist, were used).  
300 This could explain the reason for no difference for SHY and SBD between the two groups.

301 The factor analysis of the SDSC is satisfactory and corresponds approximately to the ICSD-3 criteria:  
302 the DIMS factor relates to insomnia, the SHY factor is associated with nighttime or sleep  
303 hyperhidrosis, the SBD factor is associated with sleep breathing disorders, the PARA factor relates to  
304 parasomnias and the NRSES factor is associated with circadian sleep cycle disorders and the main

305 disorders of hypersomnolence. However, precaution is advised when defining the cutoff for all factors  
306 other than insomnia. Indeed, if we applied these strictly, we would obtain for the control group: 28%  
307 sleep disorder, 26% insomnia, 21% hyperhidrosis, 28% sleep breathing disturbance, 12% parasomnia  
308 and 24% non-restorative sleep of excessive somnolence. The prevalence of breathing disturbance  
309 during sleep and excessive somnolence are very high in comparison to other studies [34]. These cut-  
310 offs should be recalculated in further studies including more heterogenous sleep pathologies. The  
311 statistical validation presented in this article also have three limits: (a) absence of test-retest fidelity,  
312 (b) absence of comparison of different age groups (for instance sleep/wake rhythms are very different  
313 in children under 12 months compared to 3 year olds) (c) the control group cannot be said to be  
314 representative of a purely non-clinical group, given that we know that the prevalence of sleep  
315 disturbances in children is high generally [20].

316

### 317 **4.3 Strengths and weaknesses in relation to other studies**

318 This is the first study on the SDSC which computes a third-order model of factorial structure. DIMS is  
319 composed of two subfactors: DIS and DMS. This difference is clinically very relevant because DMS  
320 rarely begins before 18-24 months old and is mostly associated with bedtime problems and limit-  
321 setting insomnia. Moreover, these two subtypes are congruent with different aetiologies [35] of  
322 insomnia.

323 The factor structure of the SDSC for children under 4 years old differs to other studies on older  
324 children. This seems logical because sleep characteristics develop particularly during the first 4 years  
325 of life [2]. The psychometric validation presented in this article, based on existing tools, the SDSC and  
326 the BISQ, must nevertheless be used with caution as certain variables specific to young children have  
327 not been controlled: for example, the total duration of sleep is significantly greater at this age [36]  
328 (this could explain the floor effect of item 1); daytime sleep, which is physiological under 4 years-old,  
329 is not taken into consideration (this could explain the difficulties seen for items 20 and 22). The  
330 specificity of this age can also explain why seven items engender dichotomous responses.

331 Computation of the SDSC concurrent criterion validity selected 10 items of the BISQ. Two further  
332 items were added (about screen exposure). The EFA and the CFA undertaken offered a preliminary  
333 factorial structure of an adapted version of the BISQ, named the Sleep Hygiene Scale for Children,  
334 comprising three factors. On the one hand, correlation between “Parent Attachment” and “Screen  
335 Exposure” with SDSC total score, in particular DIMS and NRSES and, on the other hand, no  
336 correlation between “Transitional coping” and SDSC total score or subscores are congruent with the  
337 literature [17,37,38]. A future study on the psychometric validation of the BISQ would be of great  
338 interest.

339

### 340 **4.4 Meaning of the study: possible implications for clinicians**

341 The SDSC can be used to detect or measure sleep disorders in young children. The correlations  
342 highlighted between certain BISQ items and the SDSC encourage the use of the SDSC in conjunction  
343 with the BISQ or its adaptation (SHSC). We note that some items of the BISQ have not been  
344 correlated with sleep disorders in this study. However, they are essential for clinical use: the position  
345 of the child's body is a crucial variable to be questioned for the prevention of sudden infant death  
346 syndrome [39], although it does not seem correlated in the present sample with sleep disorders.  
347 Similarly, the sample showed no correlation between the presence of positive rituals and sleep  
348 disorders, unlike other studies [18].

349 Regarding the analysis of the different scores obtained, a score which surpasses the threshold for the  
350 DIMS factor suggests that the clinician should provide behavioral recommendations relating to child  
351 insomnia [40] on the strength of the sleep diary. The clinician will be vigilant about screen use,  
352 nighttime feeding, nighttime and daytime wake-sleep rhythms, sleep position, co-sleeping and bedtime  
353 rituals.

354 The clinician should use caution with the SBD and NRSES factors, completing the information with a  
355 thorough clinical examination (Body Mass Index, the size of their tonsils and adenoids, quality of  
356 siestas, etc.).

357

#### 358 **4.5 Unanswered questions and future work**

359 Future studies can explore additional analyses beyond the scope of this study, such as measurement  
360 invariance. To detect if some items measured different constructs for subjects belonging to different  
361 subgroups, the uniform differential functioning of each SDSC-Y item could be studied according to  
362 age and gender using a multiple indicator multiple cause (MIMIC) model. The invariance of the  
363 measurement model used for the SDSC-Y could be investigated across age group and gender using  
364 multi-group modelling.

365 The characteristic and information curves of each item were not reported. These curves can  
366 nevertheless help us to appreciate the relevance of the item response categories and the item precision  
367 in the latent factor estimation on the latent factor scale. This could be potentially interesting if the  
368 sleep disorder scale were to be reconsidered by adding or modifying items according to experts.

369 In order to develop a Sleep Disorder Scale common to different countries, the study of the invariance  
370 of the SDSC (or SDSC-Y) measurement model across different cultural contexts would be of great  
371 interest. This supposes all participants will complete all the items of the different versions of the  
372 questionnaire. The wording of the items may need to be adapted to measure the same construct across  
373 the different cultural contexts. Given a measurement invariance across countries, the structural  
374 invariance of the questionnaire would provide useful information about the differences in the  
375 theoretical constructs across different countries.

#### 376 **Acknowledgements**

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381 adaptation of his scale.

382 **Appendix A.** French version of the Sleep Disturbance Scale for Children (SDSC) [11] used for  
 383 adaptation to a young French children population (6 months to 4 years old).  
 384

**Echelle de dépistage des troubles du sommeil de l'enfant de 6 mois à 4 ans**

Prénom de l'enfant : ..... Date de naissance : ..... Taille : .....  
 Nom de l'enfant : ..... Sexe :  Garçon  Fille Poids : .....

Pour répondre à ce questionnaire, basez-vous sur les observations que vous avez pu faire durant les six dernières mois et cochez les cases qui correspondent le mieux à ce que vous avez observé de votre enfant. Merci de répondre à toutes les questions en remplissant les lignes ou en entourant les nombres

	En semaine	En week-end
Heure approximative de coucher habituelle :	.....h.....min	.....h.....min
Heure approximative de lever matinal habituelle :	.....h.....min	.....h.....min
Combien de temps votre enfant dort-il approximativement pendant la JOURNEE (siestes) ?	.....h.....min	.....h.....min
Combien de temps votre enfant passe-t-il approximativement éveillé la NUIT ?	.....h.....min	.....h.....min

Combien de fois l'enfant se réveille-t-il la nuit ? ..... Que faites-vous ? .....

	Plus de 9h	8h à 9h	7h à 8h	5h à 7h	Moins de 5h
<b>1 - Combien d'heures l'enfant dort-il la plupart des nuits ?</b>	(1)	(2)	(3)	(4)	(5)
	Moins de 15 min	15-30 min	30-45 min	45-60 min	Plus de 60 min
<b>2 - Combien de temps après sa mise au lit l'enfant met-il habituellement pour s'endormir ?</b>	(1)	(2)	(3)	(4)	(5)
	Jamais	Rarement 1 à 3 fois / mois	Parfois 1 à 2 fois / semaine	Souvent 3 à 5 fois / semaine	Toujours Tous les jours
<b>3 - L'enfant va au lit avec réticence</b>	(1)	(2)	(3)	(4)	(5)
<b>4 - L'enfant a des difficultés à s'endormir</b>	(1)	(2)	(3)	(4)	(5)
<b>5 - L'enfant ressent de l'anxiété ou des peurs au moment de s'endormir</b>	(1)	(2)	(3)	(4)	(5)
<b>6 - Lorsque l'enfant s'endort, il semble vivre ses rêves</b>	(1)	(2)	(3)	(4)	(5)
<b>7 - L'enfant transpire excessivement à l'endormissement</b>	(1)	(2)	(3)	(4)	(5)
<b>8 - L'enfant se réveille plus de 2 fois par nuit</b>	(1)	(2)	(3)	(4)	(5)
<b>9 - L'enfant a des difficultés à s'endormir à nouveau après s'être réveillé dans la nuit</b>	(1)	(2)	(3)	(4)	(5)
<b>10 - Dans son sommeil, l'enfant a des mouvements brusques ou des secousses des jambes ou il change souvent de position durant la nuit ou encore il jette les couvertures au pied de son lit</b>	(1)	(2)	(3)	(4)	(5)
<b>11 - L'enfant a des difficultés à respirer durant la nuit</b>	(1)	(2)	(3)	(4)	(5)
<b>12 - L'enfant fait des pauses respiratoires ou cherche sa respiration pendant son sommeil</b>	(1)	(2)	(3)	(4)	(5)
<b>13 - L'enfant ronfle</b>	(1)	(2)	(3)	(4)	(5)
<b>14 - L'enfant transpire excessivement pendant la nuit</b>	(1)	(2)	(3)	(4)	(5)
<b>15 - Vous avez déjà entendu l'enfant parler dans son sommeil</b>	(1)	(2)	(3)	(4)	(5)
<b>16 - L'enfant se réveille en hurlant ou est confus au point qu'il est impossible de l'approcher, mais il n'a aucun souvenir de ces événements le matin suivant</b>	(1)	(2)	(3)	(4)	(5)
<b>17 - L'enfant fait des cauchemars dont il ne se rappelle pas le matin venu</b>	(1)	(2)	(3)	(4)	(5)
<b>18 - L'enfant est difficile à réveiller le matin</b>	(1)	(2)	(3)	(4)	(5)
<b>19 - L'enfant se réveille le matin en se sentant fatigué</b>	(1)	(2)	(3)	(4)	(5)
<b>20 - L'enfant se sent incapable de bouger quand il se réveille le matin</b>	(1)	(2)	(3)	(4)	(5)
<b>21 - L'enfant est somnolent durant la journée</b>	(1)	(2)	(3)	(4)	(5)
<b>22 - L'enfant s'endort brutalement, de façon inattendue, à l'école ou lors de ses activités</b>	(1)	(2)	(3)	(4)	(5)

Facteurs	Sommes	Scores	Seuils	Normes		
				Moyenne	Ecart-type	Q1 et Q3
Troubles du sommeil	Somme des 5 facteurs (sur 110)	.....	>37 □	34,4	9,0	28-39
A. Insomnies	1, 2, 3, 4, 5, 8, 9, 10 (sur 40)	.....	>16 □	14,2	5,0	11-17
B. Hyperhydrose	7, 14 (sur 10)	.....	>4 □	3,5	2,0	2-4
C. Problèmes respiratoires	11, 12, 13 (sur 15)	.....	>4 □	4,2	1,6	3-5
D. Parasomnies	6, 15, 16, 17 (sur 20)	.....	>7 □	6,0	2,2	4-7
E. Sommeil non réparateur et Somnolence diurne excessive	18, 19, 20, 21, 22 (sur 25)	.....	>7 □	6,5	1,9	5-7

Ces scores ne peuvent en aucun cas remplacer le diagnostic d'un spécialiste du sommeil. Si les scores A, C ou E > seuils, consultez un spécialiste.

385  
 386  
 387  
 388  
 389 *The digital version is available at <http://sommeilenfant.fr>*

390 **Appendix B.** French version of the binary items used for estimating "sleep hygiene".

391

392 In the literature, all items are associated with sleep characteristics. All items scoring "Yes" reflected bad "sleep hygiene" (except item 3).

393

Items	Questions and Items' labels	Short label	References
	Comment votre enfant s'endort-il en début de siestes ou en début de nuit ?	Bedtime conditions	[39]
1	L'enfant s'endort pendant l'allaitement	Breastfeeding at bedtime	[15]
2	L'enfant s'endort en étant bercé	Rocked at bedtime	[39]
3	L'enfant s'endort dans un lit seul*	Alone in a bed at bedtime	[39]
4	L'enfant s'endort en étant porté	Carried at bedtime	[39]
	Au moment de l'endormissement de votre enfant ou s'il se réveille durant la nuit, quel comportement adoptez-vous ?	Parental behavior during night awakenings	
5	Je sors l'enfant du lit et je le porte/le berce jusqu'à ce qu'il s'endorme	Carried at bedtime	[37]
6	J'allaite l'enfant jusqu'à ce qu'il se rendorme	Breastfeeding during the night	[15]
7	Je donne à l'enfant son doudou	Given their blanket	[37]
8	J'amène l'enfant dans mon lit	Co-sleeping	[39]
9	Je réconforte l'enfant verbalement mais je ne le sors pas de son lit	Verbally comforted without being taken out of bed	[37]
10	Je chante une chanson ou berceuse à l'enfant	Sung a lullaby during the night	[37]
	Ecrans : télévision, téléphone portable, dessins-animés, jeux video, ordinateurs	Screen exposure	[41]
11	Regarde-t-il souvent les écrans ?	Often watches screens	[41]
12	Ecran après 16h	Screen exposure after 4pm	[42]
	Questions supplémentaires :		
13	L'enfant dort-il sur le dos la plupart du temps ?	Sleep position	[39]
14	Le même rituel de coucher est réalisé tous les soirs ?	Sleep rituals	[18]

394 All items had a binary response category: 0 for No and 1 for Yes. Supplementary questions were not correlated with the SDSC-Y (they were not computed in  
 395 the scoring, nevertheless, according to international recommendations, items 13 and 14 are crucial.

396 \*reverted item: positively correlated with good sleep hygiene

397 **Appendix C. Sleep Disturbance Scale for Young Children (SDSC-Y)**  
 398 **Results Table**

399 Name: ..... Age: .....  
 400  
 401

	SDSYC	DIMS	DIMS.1	DIMS.2	SHY	SBD	PARA	NRS-DOES	
T-Score									T-Score
100	78+	37+	24	14	10	15	18+	14+	100
99	65	31	21	13		11	13	13	99
98	57	28	19	12		10	12	12	98
97	52	26	17	10	9	8	11	11	97
96	50	24	16		8	7			96
95	49		15	9			10	10	95
94		22							94
93	48		14		7	6			93
92		21	13						92
91	47						9	9	91
90	46	20			6				90
89									89
88				8			8		88
87		19				5			87
86	45		12		5				86
85									85
84	44							8	84
83	43	18							83
82	42		11						82
81							7		81
80	41								80
79		17			4				79
78	40								78
77	39		10	7					77
76								7	76
75									75
74	38	16							74
73									73
72									72
71	37		9			4			71
70									70
69							6		69
68	36								68
67									67
66		15		6					66
65									65
64									64
63	35							6	63
62			8		3				62
61									61
60		14							60
59	34								59
58									58
57									57
56									56
55									55
54	33								54
53									53
52		13		5					52
51									51
50									50
49	32		7				5		49
48									48
47									47
46					2				46
45									45
44									44
43	31								43
42		12						5	42
41									41
40				4					40
39									39
38						3			38
37	30								37
36									36
35									35
34									34
33									33
32	29	11	6						32
31									31
30									30

402



403 **Conflicts of Interest**

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406

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516 **Table 1** Indices of fit for the models obtained by exploratory factor analysis of the 22-items Sleep  
 517 Disorder Scale for Young Children (SDSC-Y)  
 518

Model	Eigenvalue	% Variance per factor	% Cumulative Variance	RMSEA	CFI	Increase in CFI (%)	Chi-Square	Degree of freedom (df)	Chi-Square / df
1-factor	7.38	33.5	34	0.099	0.847		1079.4	209	5.16
2-factor	2.26	10.3	44	0.081	0.910	6.3	704.0	188	3.74
3-factor	1.66	7.5	51	0.069	0.940	3.0	508.2	168	3.03
4-factor	1.57	7.1	58	0.061	0.960	2.0	379.1	149	2.54
5-factor	1.27	5.8	64	0.052	0.974	1.4	277.6	131	2.12
<b>6-factor</b>	<b>1.11</b>	<b>5.0</b>	<b>69</b>	<b>0.036</b>	<b>0.989</b>	<b>1.5</b>	<b>176.2</b>	<b>114</b>	<b>1.55</b>
7-factor	0.96	4.4	74	0.033	0.992	0.3	143.4	98	1.46

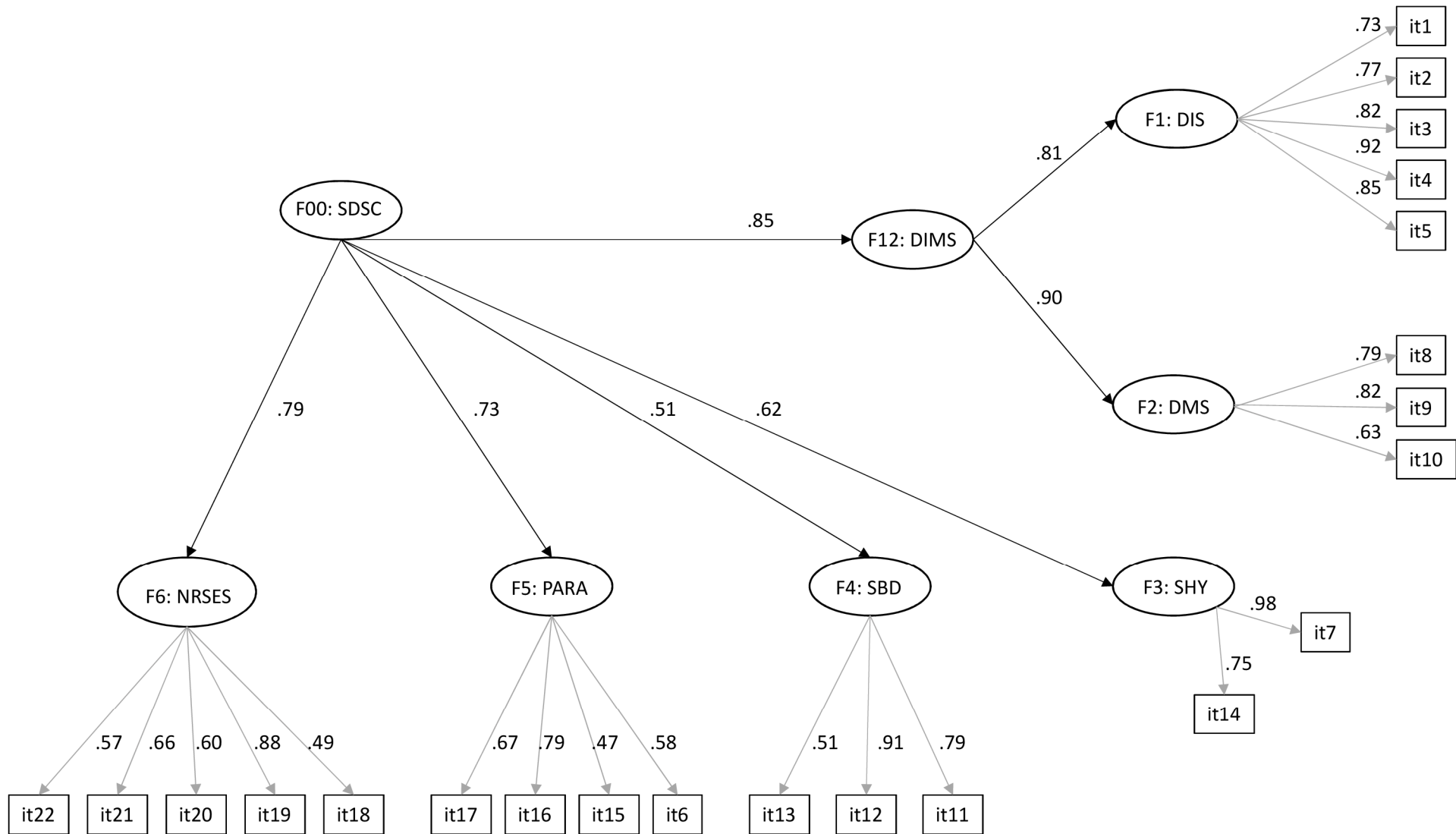
519 The line in bold indicates the factorial structure retained for the SDSC-Y

520 **Table 2.** Geomin rotated factor loadings estimated in the 6-factor model using exploratory factor  
 521 analysis of the SDSC-Y  
 522

Factor	Item short label	Variance explained	Factor loading
<b>Factor 1: Disorders of Initiating Sleep (DIS)</b>		33.5 %	
	1. Sleep duration		0.39
	2. Sleep latency		0.81
	3. Going to bed reluctantly		0.72
	4. Difficulty in falling asleep		0.97
	5. Anxiety when falling asleep anxiety		0.69
<b>Factor 2: Disorders of Maintaining Sleep (DMS)</b>		10.3%	
	8. Night awakenings		0.91
	9. Difficulty in falling asleep after awakenings		0.62
	10. Nocturnal hyperkinesia		0.37
<b>Factor 3: Sleep Hyperhidrosis (SHY)</b>		7.5%	
	7. Sweating when falling asleep		0.80
	14. Night sweating		0.85
<b>Factor 4: Sleep Breathing Disorders (SBD)</b>		7.1%	
	11. Breathing problems		0.75
	12. Sleep apnoea		0.89
	13. Snoring		0.49
<b>Factor 5: Parasomnias (PARA)</b>		5.8%	
	6. Hypnagogic hallucinations		0.26
	15. Sleepwalking		0.61
	16. Sleep terrors		0.53
	17. Nightmares		0.83
<b>Factor 6: Non-Restorative Sleep and Excessive Somnolence (NRSES)</b>		5.%	
	18. Unusually difficult to awaken in the morning		0.62
	19. Feeling tired with non-restorative sleep		0.60
	20. Sleep paralysis		0.68
	21. Daytime somnolence		0.46
	22. Sleep attacks		0.39

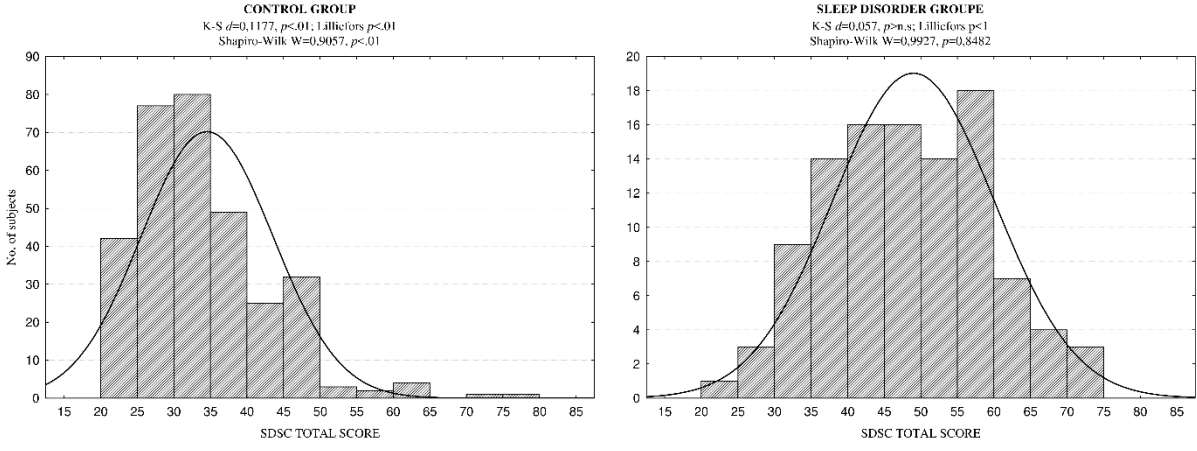
523

**Figure 1.** Third-order model of factorial structure for the Sleep Disorders Scale for Young Children (SDSC-Y).

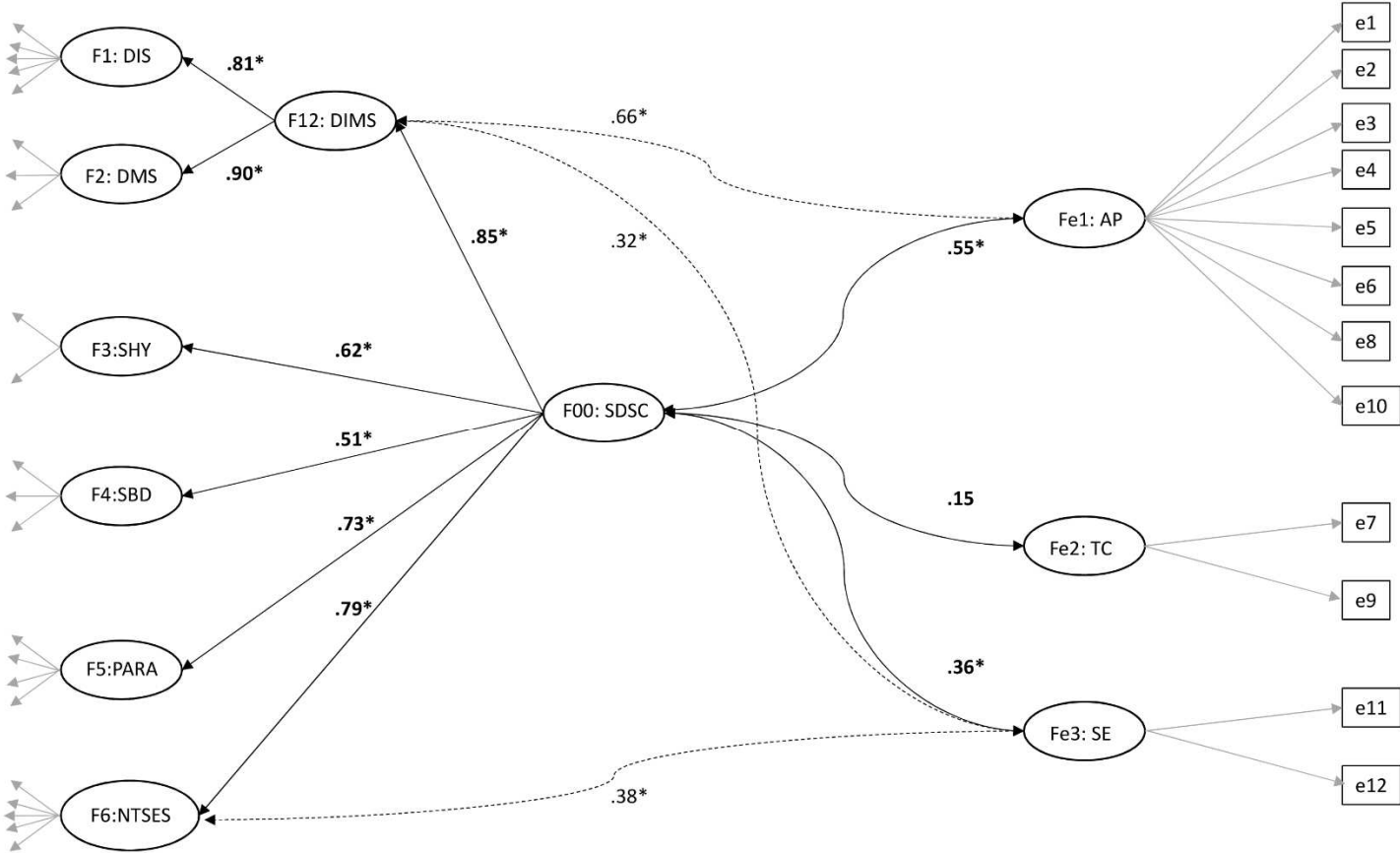


**Legend.** Item indicators are presented in square, latent variables in ellipse. Numbers in gray are the standardized coefficients for the first-order measurement model. Both latent variables F1 and F2 were supposed to be explained by a latent F12 variable. The latent variable F00 reflecting global sleep disorders was supposed to be explained by five latent variable F12, F3, F4, F5 and F6. Disorders of Initiating and Maintaining Sleep (DIMS), Disorders of Initiating Sleep (DIS), Disorders of Maintaining Sleep (DMS), Sleep Hyperhidrosis (SHY), Sleep Breathing Disorders (SBD), Parasomnias (PARA) and Non-Restorative Sleep and Excessive Somnolence (NRES).

**Figure 2.** Distribution of the Sleep Disturbance Scale for Young Children (SDSC-Y) total score for the control and clinical groups.



**Figure 3** Structural equation model used to estimate the pairwise correlations between the Sleep Disorder Scale for Young Children and the Sleep Hygiene Scale for Children.



Solid line: Structural equation model used to estimate the pairwise correlations between the global latency of SDSC and the latent subscale of the SHSC; the model had an acceptable fit (RMSEA=0.049, CFI=0.911). Dotted line: Structural equation model to estimate the pairwise correlations between the latent sub-dimensions of the SDSYC and the latent subscale of the SHSC; the model had an acceptable fit (RMSEA=0.046, CFI=0.923). The 3 SHSC sub-dimensions are: Attachment Parenting (AP); Translational Coping (TC); Screen Exposure (SE). The 5 SDSYC sub-dimensions are: Disorders of Initiating and Maintaining Sleep (DIMS), Sleep Hyperhidrosis (SHY), Sleep Breathing Disorders (SBD), Parasomnias (PARA) and Non-Restorative Sleep and Excessive Somnolence (NRES). \* indicates correlation significantly different from 0 at 5% and superior to .3.



Model	Eigenvalue	% Variance per factor	% Cumulative Variance	RMSEA	CFI	Increase in CFI (%)	Chi-Square	Degree of freedom (df)	Chi-Square / df
1-factor	7.38	33.5	34	0.099	0.847		1079.4	209	5.16
2-factor	2.26	10.3	44	0.081	0.910	6.3	704.0	188	3.74
3-factor	1.66	7.5	51	0.069	0.940	3.0	508.2	168	3.03
4-factor	1.57	7.1	58	0.061	0.960	2.0	379.1	149	2.54
5-factor	1.27	5.8	64	0.052	0.974	1.4	277.6	131	2.12
<b>6-factor</b>	<b>1.11</b>	<b>5.0</b>	<b>69</b>	<b>0.036</b>	<b>0.989</b>	<b>1.5</b>	<b>176.2</b>	<b>114</b>	<b>1.55</b>
7-factor	0.96	4.4	74	0.033	0.992	0.3	143.4	98	1.46

The line in bold indicates the factorial structure retained for the SDSC-Y

Factor	Item short label	Variance explained	Factor loading
<b>Factor 1: Disorders of Initiating Sleep (DIS)</b>		33.5 %	
	1. Sleep duration		0.39
	2. Sleep latency		0.81
	3. Going to bed reluctantly		0.72
	4. Difficulty in falling asleep		0.97
	5. Anxiety when falling asleep anxiety		0.69
<b>Factor 2: Disorders of Maintaining Sleep (DMS)</b>		10.3%	
	8. Night awakenings		0.91
	9. Difficulty in falling asleep after awakenings		0.62
	10. Nocturnal hyperkinesia		0.37
<b>Factor 3: Sleep Hyperhidrosis (SHY)</b>		7.5%	
	7. Sweating when falling asleep		0.80
	14. Night sweating		0.85
<b>Factor 4: Sleep Breathing Disorders (SBD)</b>		7.1%	
	11. Breathing problems		0.75
	12. Sleep apnoea		0.89
	13. Snoring		0.49
<b>Factor 5: Parasomnias (PARA)</b>		5.8%	
	6. Hypnagogic hallucinations		0.26
	15. Sleepwalking		0.61
	16. Sleep terrors		0.53
	17. Nightmares		0.83
<b>Factor 6: Non-Restorative Sleep and Excessive Somnolence (NRSES)</b>		5.%	
	18. Unusually difficult to awaken in the morning		0.62
	19. Feeling tired with non-restorative sleep		0.60
	20. Sleep paralysis		0.68
	21. Daytime somnolence		0.46
	22. Sleep attacks		0.39