

Supplemental Online Content

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This supplemental material has been provided by the authors to give readers additional information about their work.

eMethods 1

Characteristic of the Quebec Longitudinal Study of Child Development (QLSCD)

The Quebec Longitudinal Study of Child Development (QLSCD) is a population-based representative sample of children in the Canadian Province of Quebec, born between October 1997 and July 1998. The cohort study was designed to investigate the early childhood factors on later developmental outcomes.

The cohort recruited singletons born between October 1997 and July 1998 in each administrative region of the Canadian province of Quebec, except those born in Northern Quebec, Cree Territory, Inuit Territory, and Native reserves (2.2% of all births).

Infants were excluded if born with severe medical illnesses, born <24 or >42 weeks of gestation, from families living in Aboriginal territories or remote regions of Québec, or from non-English-and non-French-speaking families. Of 2940 families initially recruited, 2223 families participated in the study when they were 5 months old and 2120 agreed to participate in the longitudinal follow-up. Participants are being evaluated almost annually and assessments are currently taking place at age 21 years.

Data were collected in four phases, of which Phase 2 (2003–2010, ages 6, 7, 8, 10, and 12 years) and Phase 3 (2011–2015, ages 13, 15, and 17 years) were the ones inherent to our study.

eMethods 2

Seven-item parent-reported questionnaire to assess disturbed sleep in children and adolescents

1. Indicate how long in total he/she sleeps during the NIGHT (on average). Do not count the hours that your child is awake
2. Indicate how long in total he/she is awake during the NIGHT (on average).
3. In general, how many hours does your child sleep during the DAY (total of all naps)?
4. Does your child TALK in his/her sleep?
5. Does your child WALK in his/her sleep?
6. Does your child have NIGHTMARES?
7. Does your child have NIGHTTERRORS (wakes up suddenly, crying, sometimes drenched in sweat and confused)?

Each item was rated on a 4-point scale (1=never, 2=sometimes, 3=often, 4=always), except for sleep duration and time awake in bed, which were reported in number of hours and minutes, and were re-scaled to vary between 1 and 4. Sleep duration was reverse-coded to have the same direction of the other items and in the assumption that shorter sleep duration is a risk factor for depression⁴⁹.

eMethods 3

Eight-item parent-reported questionnaire to assess depression in children

1. Seemed to be unhappy or sad?
2. Was not as happy as other children?
3. Was unable to concentrate, could not pay attention for long?
4. Was too fearful or anxious?
5. Was worried?
6. Cried a lot?
7. Was nervous, highstrung or tense?
8. Had trouble enjoying HIM/HER self?

Each item was rated on a 3-point scale, (1=never, 2=sometimes, 3=often). Cronbach's alphas at 5, 7 and 8 years were 0.70, 0.72 and 0.73, respectively. A mean score was computed, and the score re-scaled to range 0-10. The higher the score, the more depressive symptoms.

eMethods 4

Ten-item self-reported questionnaire to assess depression in adolescents

1. I am unhappy or sad
2. I am not as happy as other people of my age
3. I can't concentrate, I can't pay attention
4. I am too fearful or nervous
5. I worry a lot
6. I cry a lot
7. I am nervous, high strung or tense
8. I have trouble enjoying myself
9. I have temper tantrums or easily get angry
10. I am not interested in doing activities with other children

Each item was rated on a 3-point scale (1=never, 2=sometimes, 3=often). Cronbach's alphas at 10, 12, 13, 15 and 17 years were 0.74, 0.78, 0.82, 0.88 and 0.89, respectively.

eMethods 5

Measurements' details for covariates/moderators, i.e. socio-economic status (SES), maternal depression and pubertal status

SES was the standardized composite of 5 items enquiring about parental education, occupational status, and household income (range, -3 to 3, centered at 0, higher scores indicating higher SES) ⁶³.

For maternal depression, mothers reported how often they experienced depressive symptoms on a 4-point scale (0=never, 1=sometimes, 2=often, 3=always) using a shortened version of the Center for Epidemiologic Studies Depression Scale ⁶⁴. Scores ranged from 0 to 10, with higher scores indicating higher depression.

For pubertal status, 12 and 13-year-old adolescents were provided with sex-appropriate drawings of secondary sex characteristics based on Tanner stages of pubertal development. Adolescents were asked to choose which of the drawings were most like them ⁶⁵, and Tanner scores were assigned from I, prepubertal, to V, full pubertal, accordingly (eTable 1 in the Supplement). Self-rated pubertal status has been shown to be sufficiently accurate for large epidemiologic studies ⁶⁶. The average scores were used as an overall index of pubertal status at each time point (12 years: M=2.76, SD=0.85; 13 years: M=3.50, SD=0.82). Given the high correlation of pubertal status between ages 12 and 13 years ($r=0.72$, $p<0.001$), the average score was used in further analyses (M=3.08, SD=0.81).

eResults 1: Missing data pattern for outcome variables in childhood and adolescence.

Missing data pattern for outcome variables in childhood.

Rate of missingness for depressive symptoms and disturbed sleep at each time point are provided in eTable 2 in the Supplement.

eTable 3 in the Supplement reports the characteristics of the study variables at each time point in the complete versus with-missing data subgroups. At 6 years of age, children with complete data were significantly less depressed compared to children with missing data. Furthermore, SES was lower and maternal depression was higher in those with missing data compared to those with complete data.

The missing data pattern across the 3 time points was MCAR for depressive symptoms ($\chi^2 = 14.90$, $df = 9$, $p = .09$) and missing at random (MAR) for sleep ($\chi^2 = 19.18$, $df = 9$, $p = .02$). As for depressive symptoms, there was not systematic differences in missing data related to time since enrollment. As for disturbed sleep, there was only a slight difference in missing data related to time since enrollment

Missing data pattern for outcome variables in adolescence.

Rates of missingness for depressive symptoms and disturbed sleep at each time point are provided in eTable 5 in the Supplement.

eTable 6 in the Supplement reports the characteristics of the study variables at each time point in the complete versus with-missing data subgroups. At 10 years of age, adolescents with complete data were significantly less depressed compared to adolescents with missing data. At 15 years of age, adolescents with complete data had significantly less disturbed sleep compared to adolescents with missing data. Furthermore, SES was lower and maternal depression was higher in those with missing data compared to those with complete data.

The missing data pattern across the 5 time points was MCAR for depressive symptoms ($\chi^2 = 42.45$, $df = 50$, $p = .77$) and for sleep ($\chi^2 = 56.84$, $df = 50$, $p = .24$). As for disturbed sleep and depressive symptoms, there were not systematic differences in missing data related to time since enrollment.

eResults 2: Cross-lagged paths between the insomnia index and depressive symptoms in childhood and adolescence

Cross-lagged paths between the insomnia index and depressive symptoms in childhood.

Findings showed that depressive symptoms were significantly associated with later insomnia at each time point, whereas insomnia was not associated with later depressive symptoms at any time points (eFigure 1 in the Supplement).

Cross-lagged paths between the insomnia index and depressive symptoms in adolescence.

Findings showed two unidirectional longitudinal associations, respectively from insomnia at 10 years to depressive symptoms at 12 years, and from depressive symptoms at 12 years to insomnia at 13 years (eFigure 3 in the Supplement).

eResults 3: Cross-lagged paths between disturbed sleep and depressive symptoms including the following time-points i.e. (1) 5, 7, 8, 10 years, (2) 12, 13, 15 and 17 years, and (3) 5, 7, 8, 10, 12, 13, 15 and 17 years.

Cross-lagged paths between disturbed sleep and depressive symptoms in childhood including time points 5, 7, 8 and 10 years.

Findings showed that depressive symptoms were significantly associated with later disturbed sleep, and disturbed sleep was associated with later depressive symptoms between 5 and 8 years (eFigure 2 in the Supplement).

Cross-lagged paths between disturbed sleep and depressive symptoms in adolescence including time-points 12, 13, 15 and 17 years.

Findings showed a significant path between depressive symptoms at 12 years and disturbed sleep at 13 years (eFigure 4).

Cross-lagged paths between disturbed sleep and depressive symptoms including all time-points, i.e. 5, 7, 8, 10, 12, 13, 15 and 17 years.

Findings showed longitudinal, reciprocal associations between depressive symptoms and disturbed sleep between 5 and 8 years, and unidirectional associations between depressive symptoms at 8 years and disturbed sleep at 10 years, and between depressive symptoms at 10 years and disturbed sleep at 12 years (eFigure 5 in the Supplement).

eTable 1. Tanner stage distribution for adrenarache and gonadarache for males and females

	12 years				13 years			
	Adrenar che, males (n=642)	Adrenar che, females (n=699)	Gonadar che, males (n=641)	Gonadar che, females (n=699)	Adrenar che, males (n=538)	Adrenar che, females (n=651)	Gonadar che, males (n=637)	Gonadar che, females (n=655)
Tann er I	79	52	45	40	5	15	9	10
Tann er II	261	157	278	151	91	38	94	36
Tann er III	211	260	219	343	203	164	197	261
Tann er IV	81	203	89	159	195	303	197	299
Tann er V	10	27	10	6	44	131	40	49

eTable 2: Rates of missingness for depression and disturbed sleep at each time point in childhood

Study variable	% missing
Depression, 5 years	3.37
Depression, 6 years	15.45
Depression, 8 years	17.58
Disturbed sleep, 5 years	14.86
Disturbed sleep, 6 years	22.62
Disturbed sleep, 8 years	24.46

eTable 3: Characteristics of the study variables at each time point in the complete versus with-missing data subgroups in the childhood sample

Study variable	Complete data	With-missing data	p-value
	N=971(57.5%)	N=718(42.5%)	
	<i>M (SD)</i>	<i>M (SD)</i>	
Depression, 5 years	2.33 (1.49)	2.32 (1.44)	0.93
Depression, 6 years	2.37 (1.52)	2.59 (1.56)	0.01
Depression, 8 years	2.49 (1.59)	2.58 (1.54)	0.31
Disturbed Sleep, 5 years	1.50 (0.20)	1.49 (0.21)	0.54
Disturbed Sleep, 6 years	1.46 (0.19)	1.47 (0.21)	0.90
Disturbed Sleep, 8 years	1.38 (0.20)	1.40 (0.20)	0.13
Sex (male%)	52.32	47.91%	0.07
Socio-economic status	0.13 (0.91)	-0.09 (0.99)	<0.001
Maternal depression	1.42 (1.61)	1.66 (1.82)	0.02

Differences between groups were tested by T-test, 2 sided for all variables except for Sex, for which a chi-squared test was used

eTable 4: Rates of missingness for depression and disturbed sleep at each time point in adolescence

10 years	% missing
Depression, 10 years	7.99
Depression, 12 years	3.23
Depression, 13 years	6.20
Depression, 15 years	3.05
Depression, 17 years	12.58
Disturbed sleep, 10 years	15.72
Disturbed sleep, 12 years	6.47
Disturbed sleep, 13 years	14.91
Disturbed sleep, 15 years	10.60
Disturbed sleep, 17 years	19.94

eTable 5: Characteristics of the study variables at each time point in the complete versus with-missing data subgroups in the adolescence sample

Study variable	Complete data	With-missing data	p-value
	N=533(47.9%)	N=580(52.1%)	
	<i>M (SD)</i>	<i>M (SD)</i>	
Depression, 10 years	2.69 (1.57)	2.95 (1.63)	<0.01
Depression, 12 years	2.29 (1.65)	2.38 (1.70)	0.39
Depression, 13 years	2.16 (1.77)	2.29 (1.87)	0.27
Depression, 15 years	3.22 (2.14)	3.34 (2.22)	0.39
Depression, 17 years	3.59 (2.23)	3.75 (2.30)	0.26
Disturbed sleep, 10 years	1.55 (0.22)	1.57 (0.24)	0.13
Disturbed sleep, 12 years	1.52 (0.21)	1.54 (0.24)	0.12
Disturbed sleep, 13 years	1.52 (0.21)	1.54 (0.22)	0.38
Disturbed sleep, 15 years	1.44 (0.19)	1.47 (0.22)	0.03
Disturbed sleep, 17 years	1.43 (0.22)	1.43 (0.22)	0.90
Sex^a	54.03	51.21%	0.12
Socio-economic status	0.26 (0.87)	-0.06 (0.91)	0.001
Maternal depression	1.21 (1.19)	1.48 (1.36)	<0.001

Differences between groups were tested by T-test, 2 sided for all variables except Sex, for which a chi-squared test was used

eTable 6. Correlation matrix between disturbed sleep and depression in childhood.

	Depression, 5 years	Depression, 7 years	Depression, 8 years	Disturbed sleep, 5 years	Disturbed sleep, 7 years	Disturbed sleep, 8 years
Depression, 5 years	-					
Depression, 7 years	0.59 **	-				
Depression, 8 years	0.48 **	0.52 **	-			
Disturbed sleep, 5 years	0.20 **	0.21 **	0.18 **	-		
Disturbed sleep, 7 years	0.23 **	0.24 **	0.21 **	0.49 **	-	
Disturbed sleep, 8 years	0.18 **	0.21 **	0.27 **	0.43 **	0.54 **	-

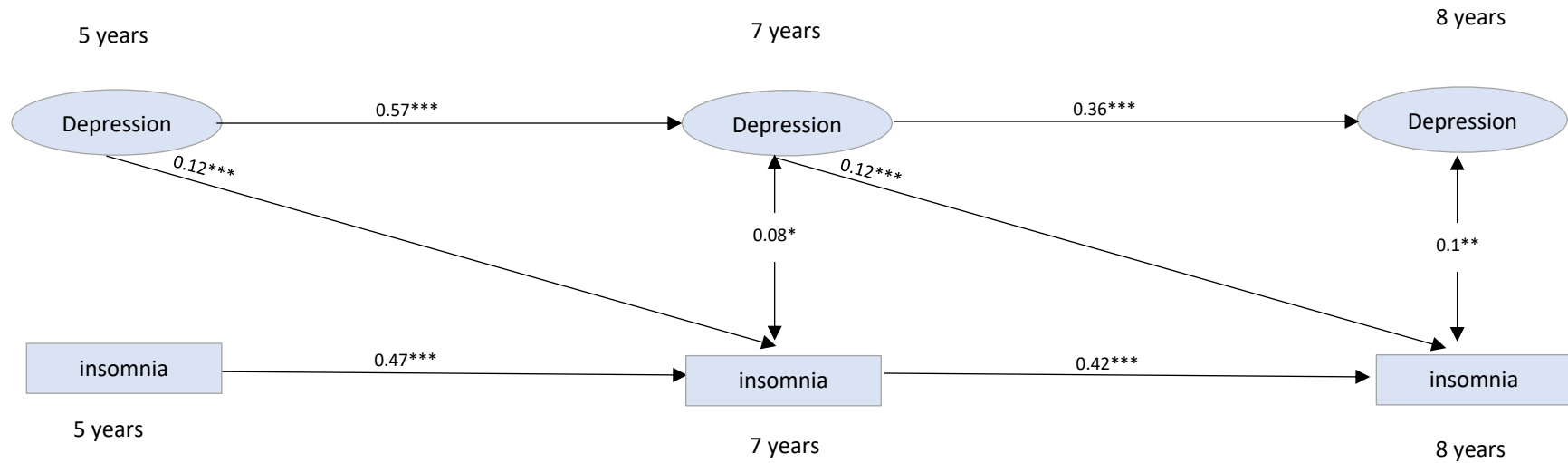
*p<0.05; **p<0.01; ***p<0.001. Data are courtesy of the Quebec Institute of Statistics.

eTable 7. Correlation matrix between disturbed sleep and depression in the adolescence sample.

	Depression, 10 years	Depression, 12 years	Depression, 13 years	Depression, 15 years	Depression, 17 years	Disturbed sleep, 10 years	Disturbed sleep, 12 years	Disturbed sleep, 13 years	Disturbed sleep, 15 years	Disturbed sleep, 17 years
Depression, 10 years	-									
Depression, 12 years	0.38 **	-								
Depression, 13 years	0.32 **	0.56 **	-							
Depression, 15 years	0.20 **	0.37 **	0.48 **	-						
Depression, 17 years	0.16 **	0.34 **	0.41 **	0.62 **	-					
Disturbed sleep, 10 years	0.09 **	0.13 **	0.12 **	0.10 **	0.07 *	-				
Disturbed sleep, 12 years	0.15 **	0.17 **	0.10 **	0.12 **	0.11 **	0.63 **	-			
Disturbed sleep, 13 years	0.07 *	0.17 **	0.15 **	0.12 **	0.13 **	0.59 **	0.64 **	-		
Disturbed sleep, 15 years	0.13 **	0.16 **	0.15 **	0.16 **	0.13 **	0.53 **	0.58 **	0.57 **	-	
Disturbed sleep, 17 years	0.10 **	0.18 **	0.19 **	0.14 **	0.18 **	0.47 **	0.50 **	0.46 **	0.60 **	-

*p<0.05; **p<0.01; ***p<0.001. Data are courtesy of the Quebec Institute of Statistics.

eFigure 1. Estimates from the cross-lagged model for the reciprocal associations between the insomnia index and depression across childhood (n=1689).



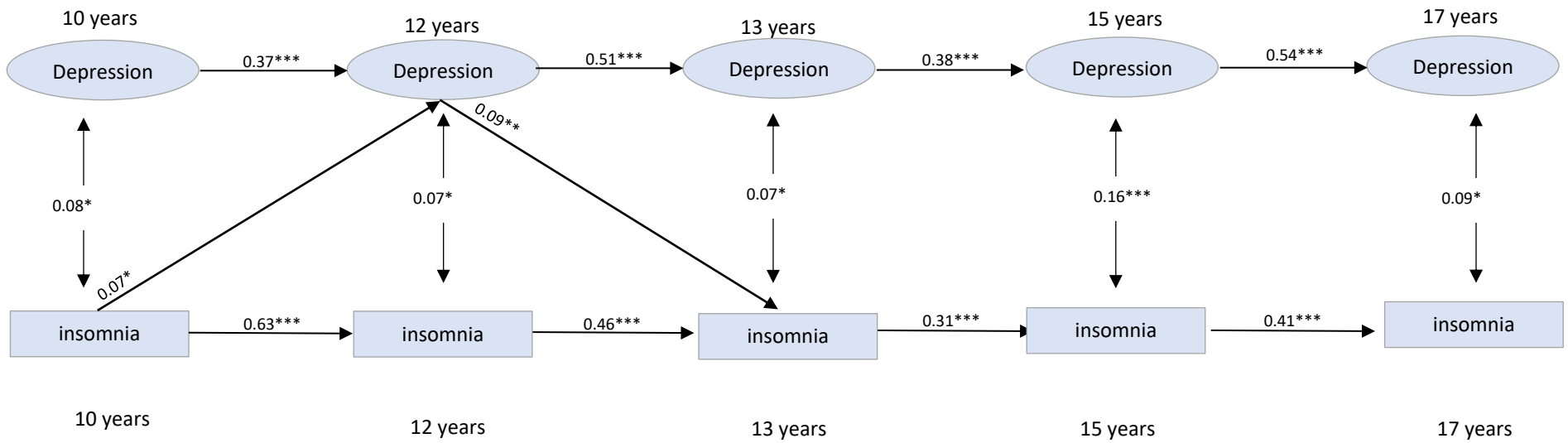
eFigure 1 legend

Source. Data are courtesy of the Quebec Institute of Statistics.

All estimates are standardized. Fit statistics: Chi-square=66.678(16), $p < .001$; RMSEA=0.043[0.033, 0.054]; CFI=0.961; TLI=0.919. CFI = comparative fit index; TLI = Tucker Lewis index; RMSEA= root mean square error of approximation. Covariates were socio-economic status and maternal depression. Non-significant paths are not shown.

P-values less than 0.05 were considered statistically significant. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

eFigure 2. Estimates from the cross-lagged model for the reciprocal association between the insomnia index and depression across adolescence (n=1113).



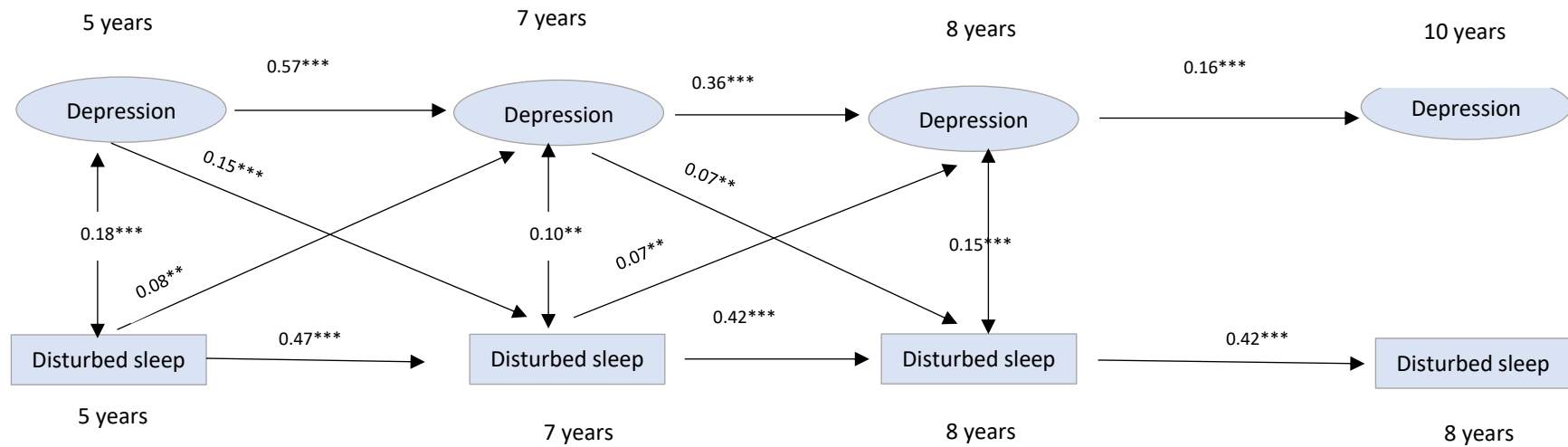
eFigure 2 legend

Source. Data are courtesy of the Quebec Institute of Statistics.

All estimates are standardized. Fit statistics: Chi-square=53.710(28), $p=0.0024$; RMSEA=0.029[0.017, 0.040]; CFI=0.988; TLI=0.972. CFI = comparative fit index; TLI = Tucker Lewis index; RMSEA= root mean square error of approximation. Covariates were socio-economic status and maternal depression. Non-significant paths are not shown.

P-values less than 0.05 were considered statistically significant. * $p<0.05$; ** $p<0.01$; *** $p<0.001$.

eFigure 3. Estimates from the cross-lagged model for the reciprocal associations between disturbed sleep and depression across childhood including 10 years of age (n=1689).



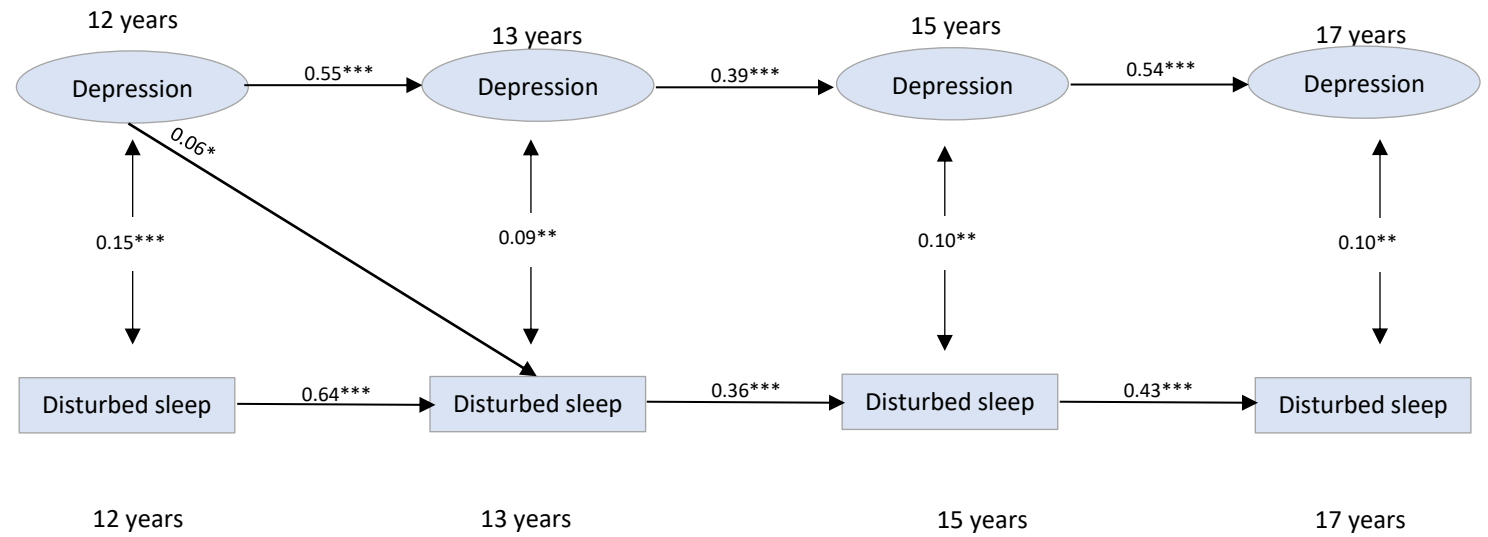
eFigure 3 legend

Source. Data are courtesy of the Quebec Institute of Statistics.

All estimates are standardized. Fit statistics: Chi-square=88.138(28), $p < .001$; RMSEA=0.036 [0.027, 0.044]; CFI=0.976; TLI=0.955. CFI = comparative fit index; TLI = Tucker Lewis index; RMSEA= root mean square error of approximation. Covariates were socio-economic status and maternal depression. Non-significant paths are not shown.

P-values less than 0.05 were considered statistically significant. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

eFigure 4. Estimates from the cross-lagged model for the reciprocal association between disturbed sleep and depression across adolescence excluding the 10-year-old time point (n=1113).



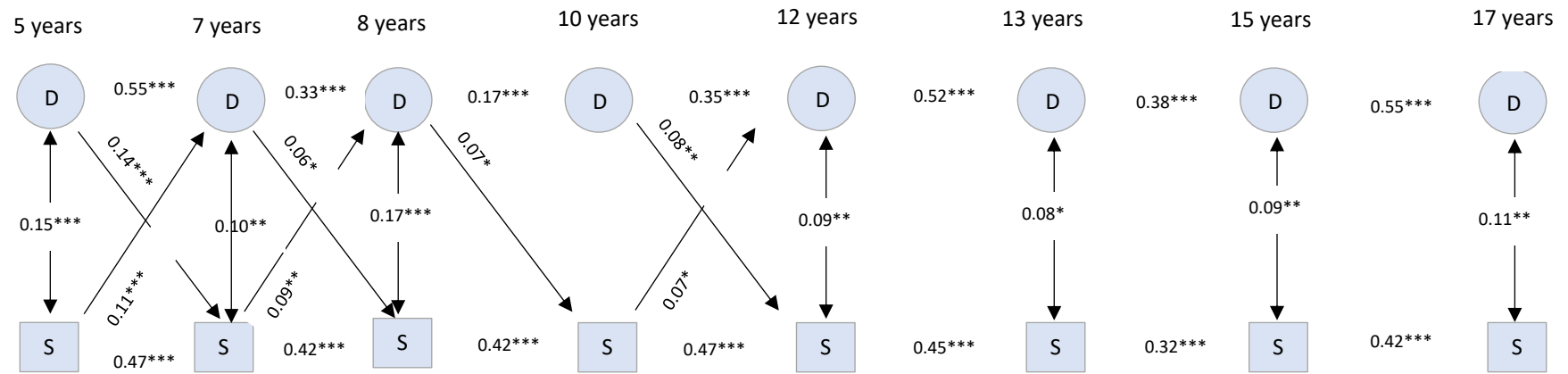
eFigure 4 legend

Source. Data are courtesy of the Quebec Institute of Statistics.

All estimates are standardized. Fit statistics: Chi-square=29.937(18), $p < .038$; RMSEA=0.024 [0.006, 0.039]; CFI=0.995; TLI=0.988. CFI = comparative fit index; TLI = Tucker Lewis index; RMSEA= root mean square error of approximation. Covariates were socio-economic status and maternal depression. Non-significant paths are not shown.

P-values less than 0.05 were considered statistically significant. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

eFigure 5. Estimates from the cross-lagged model for the reciprocal associations between disturbed sleep and depression from 5 to 17 years of age (n=1085).



eFigure 5 legend

Source. Data are courtesy of the Quebec Institute of Statistics.

All estimates are standardized. Fit statistics: Chi-square=155.200(88), $p < .001$; RMSEA=0.027 [0.020, 0.033]; CFI=0.987; TLI=0.978. CFI = comparative fit index; TLI = Tucker Lewis index; RMSEA= root mean square error of approximation. Covariates were socio-economic status and maternal depression. Non-significant paths are not shown.

P-values less than 0.05 were considered statistically significant. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

D=depression

S= disturbed sleep