Longitudinal relationships between maternal depressive/anxious symptoms and children's tics

Tomoko Yagi (tomokoyagi1112@gmail.com)
The University of Tokyo
Shuntaro Ando
The University of Tokyo
Satoshi Usami
The University of Tokyo
Syudo Yamasaki
Tokyo Metropolitan Institute of Medical Science
Masaya Morita
The University of Tokyo
Tomoki Kiyono
The University of Tokyo
Noriyuki Hayashi
The Univeristy of Tokyo
Kaori Endo
Tokyo Metropolitan Institute of Medical Science
Yudai Iijima
Tokyo Metropolitan Institute of Medical Science
Yuko Morimoto
The Graduate University of Advanced Studies
Sho Kanata
Teikyo University School of Medicine
Shinya Fujikawa
The University of Tokyo
Shinsuke Koike
The University of Tokyo
Yukiko Kano
The University of Tokyo
Mariko Hiraiwa-Hasegawa
The Graduate University of Advanced Studies
Atsushi Nishida
Tokyo Metropolitan Institute of Medical Science
Kiyoto Kasai
The University of Tokyo

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Abstract

Background Previous studies have revealed an association between maternal depressive/anxious symptoms and children's tics. However, the longitudinal relationship between these symptoms remains unclear. We examined the longitudinal relationships between maternal depressive/anxious symptoms and children's tics across early adolescence in a population-based sample.

Methods Participants were 3,171 children and their mothers from the Tokyo Teen Cohort study (TTC), a population-representative longitudinal study launched in Tokyo in 2012. Maternal depressive/anxious symptoms and children's tics were examined using self-report questionnaires at the ages of 10 (time 1, T1) and 12 (time 2, T2). A cross-lagged model was used to explore the relationships between maternal depressive/anxious symptoms and children's tics.

Results As maternal depressive/anxious symptoms at T1 were greater, their children at T2 were more likely to have tics (β = .06, p = .001). Furthermore, the presence of tics at T1 was positively related to maternal depressive/anxious symptoms at T2 (β = .06, p = .001).

Conclusions These findings suggest a longitudinal bidirectional relationship between maternal depressive/anxious symptoms and children's tics during early adolescence which may exacerbate each other over time and possibly create a vicious circle. When an early adolescent has tics, it might be important to identify and care for maternal depressive/anxious symptoms.

Background

Tics are so common that ICD-10 describes tics can be seen in about 10–20% of children in general population (1–4) although a rate of medical consultation rate of children with tics is low (5, 6). Tics tend to be remitted with age (7–12), but tics pose a psycho-social burden on children and their family (7, 13, 14). Drug and behavioral therapies are the means to directly reduce tics (7), but there are problems such as side effects of drug therapy and limited facilities available for behavioral therapy. Therefore, if it is understood that family depressive/anxious symptoms affect children's tics, family depressive/anxious symptoms can be changeable intervention points.

There has been a growing interest in relationships between maternal mental health and children with tics (15–17). Postnatal maternal anxious symptoms and prenatal maternal depressive symptoms have been increased the odds of their children having Tourette syndrome (TS)/chronic tic disorder (CT) at age 13 (18). In another study, maternal history of nonspecific psychiatric disorders, including anxiety disorders and depressive disorders, increased the odds of children having TS/CT during their childhood and adolescence (19). It was presumed that maternal depressive/anxious symptoms were associated with the occurrence of their children's TS/CT via maternal-specific environmental and/or genetic factors (18, 19).

However, since no studies have examined the relationship between maternal depressive/anxious symptoms and children's tics with a longitudinal design, it is not known whether maternal depressive/anxious symptoms predict a later course of children's tics. If maternal depressive/anxious symptoms influence the subsequent course of tics, maternal depressive/anxious symptoms could possibly be an intervention point. Additionally, we speculated that maternal depressive/anxious symptoms and children's tics influence each other bidirectionally and that a vicious circle may arise between the two.

Our aim was therefore to examine the relationships between maternal depressive/anxious symptoms and their children's tics in a longitudinal study design using general population adolescent samples. Our hypotheses were as follows: 1) maternal depressive/anxious symptoms predict the presence of children's tics two years later; 2) maternal depressive/anxious symptoms and children's tics influence each other bidirectionally over time.

Method

Participants

This study used data from the Tokyo Teen Cohort study (TTC, http://ttcp.umin.jp/), a population-based longitudinal survey focusing on children's health from biopsychosocial multidisciplinary viewpoints. The TTC was conducted from October 2012, and the participants were recruited from three municipalities in Tokyo (Setagaya, Mitaka, and Chofu) using the Basic Resident Register. The candidate participants included 14,553 children born between September 1, 2002, and August 31, 2004. Invitation letters were sent to the primary parents of those children around their tenth birthday. Of these children, 10,234 could be contacted, and the children were invited to

participate in the cohort study. Of the 10,234 children, 4,478 children participated in the baseline survey named the Tokyo Early Adolescence Survey (T-EAS) (20-24). This baseline survey was conducted from October 2012 to January 2015 when participants were approximately 10 years old (time 1, T1). Then, we carried out an adjustment of the social economic status for the participants in this baseline survey, and 3,171 participants were extracted as a target of TTC. The second wave in TTC was carried out from August 2014 to December 2016 at the time the participants were approximately 12 years old (time 2, T2), and the follow-up rate was 94.8%.

Ethical approval

Ethical approval for this study was obtained from the research ethics committees of Tokyo Metropolitan Institute of Medical Science (Approval number: 12-35), SOKENDAI (The Graduate University for Advanced Studies) (2012002), and the Graduate School of Medicine and Faculty of Medicine, The University of Tokyo (10057). We obtained informed assent from children and written informed consent from primary parents (mostly mothers). In each wave of data collection, trained interviewers visited participants' homes. They distributed questionnaires to the children and primary parents and conducted psychological tests for the children.

Measures

Tics

We evaluated tics at T1 and T2. Participants' primary parents answered the questionnaire about children's tics, which had been used in a previous study (15). The questionnaire included a section with five questions about specific motor and vocal tics in the past year: Q1: Has your child had any repeated movements of parts of the face and head (e.g., eye blinking, grimacing, sticking tongue out, licking lips, spitting)?; Q2: Has your child had repeated movements of the neck, shoulder or trunk (e.g., twisting around, shoulder shrugging, bending over, nodding)?; Q3: Has your child had repeated movements of arms, hands, legs, feet?; Q4: Has your child had repeated noises and sounds (e.g., coughing, clearing throat, grunting, gurgling, hissing)?; Q5: Has your child had repeated words or phrases?. Each question was answered as "definitely", "probably" or "not at all" present. Furthermore, we asked the following question about the frequency of these repetitive behaviors: "Q6: About how often does/did this happen in the last year?". This question was answered on a 5-Likert scale: "1: Less than once a month, 2: 1-3 times a month, 3: About once a week, 4: More than once a week, 5: Every day."

We evaluated presence of tics by binary valuables; with tics or without tics. We defined participants who responded "Definitely" or "Probably" to any of Q1, Q2, and Q4 as having tics. Participants who only endorsed repeated movements of the arms, hands, legs or feet (Q3) or repeated words or phrases (Q5) in the absence of a positive response to other questions about types of tics (Q1, Q2, Q4) were excluded from all case definitions to remove nontic movements such as stereotypy or isolated echolalia. We defined all responses of "definitely" or "Probably" to motor and/or vocal tic as tics regardless of the frequency because there is no condition of the frequency in diagnostic criteria of tic disorders (25) and because we aimed to exhaustively find tics in the general population. In post hoc analyses, we used a narrower definition of tics that required a frequency of the motor and/or vocal tic of twice a week or more.

Maternal depressive/anxious symptoms

We employed the Kessler Psychological Distress Scale (K6) (26-28) for T1 and the General Health Questionnaire-28 (GHQ-28) (29, 30) for T2. The K6 and the GHQ-28 are both widely used self-reported questionnaires developed to evaluate depressive/anxious symptoms. If primary parents other than mothers answered the K6 or GHQ-28, we regarded those responses as missing values. In this study, we used raw values of K6 and GHQ-28 as continuous scales not as screening scales for the purpose of evaluating the severity of depressive/anxious symptoms including normal range in general population. Cronbach's alpha was .84 for K6, and .88 for GHQ-28. We found the distributions of K6 and GHQ-28 were similar by the graphing cumulative distribution of the Z score of K6 and GHQ-28.

Other variables

Sex (7, 15, 31), age (9, 10, 32), maternal age (17, 19, 33, 34), socioeconomic status (35), and maternal alcohol use during pregnancy (36) were included in the analyses since previous studies reported that these factors influenced the occurrence of TS/CT. To assess socioeconomic status, family income was evaluated on a 10-point scale, which ranged from "0-990,000 yen" to "more than 10,000,000 yen". Information on maternal alcohol use during pregnancy was obtained from maternity record books that were provided for almost all mothers by local public organizations in Japan.

Statistical analysis

Longitudinal relationships between maternal depressive/anxious symptoms and children's tics were studied with structural equation modeling (Figure 1). We used SPSS® (Statistical Package for Social Science; IBM Corp., Armonk, N.Y. USA) version 21.0 for characteristics of the study participants and Amos ver. 22.0 (IBM Corp, New York) for structural equation modeling. We used the following three cross-lagged design models. The first model analyzed the longitudinal relationships between maternal depressive/anxious symptoms and children's tics without adjusting covariates (unadjusted model). The second model adjusted for sex, age in months, family income, maternal age, and maternal alcohol use during pregnancy (adjusted model). Finally, we took into account the nonnormal distribution of particular dependent variables (maternal depressive/anxious symptoms and children's tics at T2), logarithmically converted these measures and conducted the analysis (logarithmically transformed model).

We also conducted post hoc analysis by using a narrower definition of tics, which had been used in a previous study about the prevalence of TS/CT (15). The aims of the post hoc analysis were to compare the prevalence of tics in this study with the previous study and to examine the stability of the results on the relationships between maternal depressive/anxious symptoms and children's tics.

Missing values in tics, maternal depressive/anxious symptoms, and covariates were accounted for by full information maximum likelihood procedures available in Amos. This method estimates model parameters and standard errors using all available data while adjusting for the uncertainty associated with missing data (37).

A threshold for statistical significance was set to $p < .05$ (two-sided) for all analyses. We evaluated the fit of our models by using the comparative fit index (CFI) and the root mean square error of approximation (RMSEA). A good model fit was indicated by an RMSEA value smaller than .05 and a CFI value larger than .95 (38, 39).

Results

Characteristics of the study participants

Table1 shows the demographic characteristics of the 3,171 study participants. Of the 3,171 included children, 2,601 children (82.0%) had complete data about tics across both time points, and 86 (2.7%) and 503 (15.9%) children had missing data about tics in T1 and T2, respectively. Across both time points, data about maternal depressive/anxious symptoms were complete for 2,683 mothers (84.6%); 179 (5.6%) and 464 (14.6%) mothers had missing scores in T1 and T2, respectively.

Of these, 23.9% children (744 of 3,109 available data) at T1 and 23.6% children (632 of 2,674 available data) at T2 had tics. Comparing the presence of tics between T1 and T2 using McNemar's test, we found no significant difference ($p = .42$). Of the 2,612 people whose data on the presence of tics were obtained in both T1 and T2, 343 participants endorsed tics at both T1 and T2, 290 participants endorsed tics only for T1, 270 participants endorsed tics for only T2, and 1,724 did not endorse tics at either time point.

Longitudinal relationships between maternal depressive/anxious symptoms and children's tics

We investigated the relationships between maternal depressive/anxious symptoms and children's tics in a cross-lagged model analysis (Figure 1, Table 2). There was a cross-sectional association between maternal depressive/anxious symptoms and children's tics at T1 and T2. More maternal depressive/anxious symptoms at T1 significantly increased the presence of tics at T2. In contrast, when children had tics at T1, maternal depressive/anxious symptoms increased at T2. All of these models indicated acceptable model fit to the data. These results revealed that maternal depressive/anxious symptoms and children's tics had longitudinal, bidirectional relationships with each other.

Post hoc analysis: analysis with a narrower definition of tics

Using a narrower definition of tics, 14.0% at the age of 10 (431 out of 3,085 effective data) and 12.1% at the age of 12 (323 out of 2,668 effective data) had tics among participants in this study. The presence of tics at T2 was significantly decreased from T1 (p = .003). We found longitudinal, bidirectional relationships between maternal depressive/anxious symptoms and children's tics (Table 3).

Discussion

This was the first study to examine the longitudinal relationships between maternal depressive/anxious symptoms and children's tics in a population-based adolescent sample. The following two findings were obtained. First, with more severe maternal depressive/anxious symptoms, children were more likely to present tics two years later. Second, there were longitudinal bidirectional relationships between maternal depressive/anxious symptoms and children's tics.

Several explanations may be possible for the significant magnitude-response relationship of maternal depressive/anxious symptoms with later children's tics. First, maternal depressive/anxious symptoms may affect the occurrence, persistence, and exacerbation of their children's tics as an environmental factor because environmental factors such as psychosocial stresses are known to exacerbate tics (40-44). Mother with depressive/anxious symptoms may have difficulty looking after their children appropriately, and their children might easily have psychological stress. Second, there might be genetic relationships between maternal depressive/anxious symptoms and the occurrence, persistence, and exacerbation of tics. TS has genetic correlations with depressive disorders and anxiety disorders, although these correlations are possibly mediated through the presence of obsessive compulsive disorder (OCD) and attention deficit hyperactivity disorder (ADHD) (45). There had been no research examining the genetic relationships between maternal depressive/anxious symptoms and the persistence or exacerbation of tics, but the results in this research could not rule out these possibilities. Furthermore, there is also a possibility that an interaction of genetic and environmental factors is involved in the relationships between maternal depressive/anxious symptoms and children's tics. The results of this study could not distinguish genetic and environmental contributors to the relationships between maternal depressive/anxious symptoms and children's tics.

The presence of tics in early adolescence predicted increased maternal depressive/anxious symptoms after two years. One of the possible mechanisms is that the parenting stress associated with bringing up children with tics might have influenced maternal depressive/anxious symptoms. Parents of children with TS experience increased caregiver burden and parenting stress compared with parents of children without TS (46, 47). Two causes could be considered for the parenting stress in parents of children with tics: the influence of tics themselves and comorbidities. Tics could have a negative impact on family relationships because tics are likely to cause social misperceptions or stigma (14, 48-50). Parents could become overprotective of, worried about, struggling to accept or trying to control children's tics (14). Previous studies have indicated that parenting stress in parents of children with tics could also occur from comorbidities, such as ADHD, OCD, and behavioral problems (46, 47). Regarding other mechanisms underlying the effect of tics on maternal depressive/anxious symptoms, genetic factors and genetic environment interactions were suggested to exist as mentioned in the previous paragraph.

In a post hoc analysis, we used a narrower definition of tics, and the prevalence rates of tics were 14.0% at the age of 10 and 12.1% at the age of 12. When a previous study using the same definition of tics as "broad definition of Tourette syndrome + chronic tic disorder", that was reported a prevalence rate of 11.8% at the age of 13 (15). Considering that tics decrease slowly from early adolescence (3, 7-9, 51-53), prevalence rates in this study were in concordance with the previous study. Using a narrower definition of tics, we also found the longitudinal bidirectional relationships between maternal depressive/anxious symptoms and children's tics.

In sum, the results of this longitudinal study showed longitudinal bidirectional relationships between maternal depressive/anxious symptoms and tics in early adolescence. This may suggest a vicious circle in which maternal depressive/anxious symptoms make tics worse, and tics make maternal depressive/anxious symptoms worse.

The strengths of this study include that this was the first demonstration of the longitudinal relationships between maternal depressive/anxious symptoms and children's tics. Other strengths were the large sample size, high persistence rate, and inclusion of nonclinical tics. In contrast, this study also had several limitations. First, we used different measures of maternal depressive/anxious symptoms for T1 and T2. We found the distributions of K6 and GHQ-28 were similar by the graphing cumulative distribution of the Z score of K6 and GHQ-28. Also, this limitation did not influence the path from maternal depressive/anxious symptoms to children's tics. Second, in this study, maternal depressive/anxious symptoms and children's tics were evaluated not by direct clinical assessments but by questionnaires to caregivers. However, we deliberately chose rigorous tic definitions and sought to exclude participants with nontic movement disorders (e.g., stereotypies associated with autism or intellectual disability, repetitive arm/leg movements that could be better explained by tremor or motor restlessness) (15). In this study, the prevalence of tics was 23.9% at age 10 and 23.6% at age 12. These prevalence rates could be considered reasonable based on the following evidence. Although estimates of the prevalence of tics span a wide range (10, 54), currently, the point prevalence of tics is estimated to be approximately 20% at childhood (1). In previous studies that directly observed children, tics was found in 29.2% of children in the fourth grade in an elementary school in Washington D.C. (4), and in 21.2% of children at the age of 9-17 years old (mean 13.1 years old) in New York (55). The prevalence rates of tics in the present study were consistent with these previous studies. Third, we did not ask detailed questions about child or maternal mental health diagnoses (major depressive disorder, anxiety disorder, tic disorder, ADHD, and OCD), so we could not adjust these variables. Parental psychiatric diagnoses are associated with child's TS/CT (19). ADHD and OCD are common comorbidity with tic disorders and cause distress to the family (45). The forth limitation would be that mothers who had severe depressive/anxious symptoms might overestimate or overlook children's tics. Fifth, the research interval in this longitudinal study was relatively short. Typically, tics improve gradually during adolescence with repeated periods of remission and exacerbation. Thus, it might be difficult to capture the change in the short research period of two years. Longer-term follow-up is needed in the future. Finally, there are also some limitations inherent to the cross-lagged model (56). There's a possibility that there are multiple potential additional factors (not included in the model) that influence the bidirectional relationship over time.

This study first showed the relationships between preceding maternal depressive/anxious symptoms and increased risk of children's tics two years later in early adolescence. Furthermore, we found longitudinal bidirectional relationships between maternal depressive/anxious symptoms and children's tics. Although we could not separate environmental factors and genetic factors in this research, these findings implied that it may be important to care not only for children with tics but also their mothers' depressive/anxious symptoms when we treat tics in early adolescence.

Conclusion

Previous studies revealed the association between maternal depressive/anxious symptoms and children's tics. However, few studies have examined this association longitudinally, so the effect of maternal depressive/anxious symptoms towards the course of tics was unknown. We examined the longitudinal relationships between maternal depressive/anxious symptoms and children's tics across early adolescence in a population-based sample. Our results demonstrated that with more severe maternal depressive/anxious symptoms, children were more likely to present tics two years later. This study also implied a longitudinal bidirectional relationship between maternal depressive/anxious symptoms and children's tics during early adolescence which may exacerbate each other over time and possibly create a vicious circle. Although we could not separate environmental factors and genetic factors in this research, we can speculate that it may be important to care not only for children with tics but also their mothers' depressive/anxious symptoms when we treat tics in early adolescence.

Abbreviations

ADHD: attention deficit hyperactivity disorder

CFI: comparative fit index

CI: confidence interval

CT: chronic tic disorder

DSM-5: Diagnostic and Statistical Manual of Mental Disorders 5th edition

GHQ-28: General Health Questionnaire-28

K6: Kessler Psychological Distress Scale

OCD: obsessive compulsive disorder

RMSEA: root mean square error of approximation

SD: standard deviation

TS: Tourette syndrome

TTC: Tokyo TEEN Cohort

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the research ethics committees of Tokyo Metropolitan Institute of Medical Science (Approval number: 12-35), SOKENDAI (The Graduate University for Advanced Studies) (2012002), and the Graduate School of Medicine and Faculty of Medicine, The University of Tokyo (10057). We obtained informed assent from children and written informed consent from primary parents prior to engaging them in research.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

TY conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript, being supervised by SA, AN, SY, and YK designed the study and reviewed and revised the manuscript. KK critically reviewed the manuscript for important intellectual content. SU supervised the statistical analysis. All authors contributed to and have approved the final manuscript.

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Tables

Table 1 Demographic characteristics of the participants

Variables	T1 (10 years of age)		T2 (12 years of age)		*p* value[a)]
	n/*Mean*	(%)/*SD*	n/*Mean*	(%)/*SD*	
Sex, male	1,684	(53.1%)			
Age in months	*122.1*	*3.3*	*146.0*	*3.7*	
Maternal age	*42.0*	*4.2*			
Family income[b)]					
< 5 million yen	620	(20.4%)	448	(16.5%)	
≥ 5 million yen, < 8 million yen	941	(31.0%)	782	(28.8%)	
≥ 8 million yen, < 10 million yen	568	(18.6%)	518	(19.1%)	
≥ 10 million yen	917	(30.1%)	970	(35.7%)	
Maternal alcohol use during pregnancy	748	(27.2%)			
Presence of tics					
With tics	744	(23.9%)	632	(23.6%)	.42
Without tics	2,365	(76.1%)	2,042	(76.4%)	
Presence of tics (narrower definition in post hoc analysis)					
With tics	431	(14.0%)	323	(12.1%)	.003**
Without tics	2,654	(86.0%)	2,345	(87.9%)	
Maternal depressive/anxious symptoms					
T1, K6	2.9	3.3			
T2, GHQ-28			5.4	4.9	

Abbreviations: SD, standard deviation.

a. McNemar's test was used to compare the presence of tics between T1 and T2.

b. Family income was evaluated on the 10-point scale described in the Method section and categorized into the four groups in this table.

** $p < .01$

Table 2 Relationships between maternal depressive/anxious symptoms and children's tics (N = 3,171)

Path	Unadjusted model					Adjusted model					Logarithmically transformed model				
	β	B	SE	95% CI	p value	β	B	SE	95% CI	p value	β	B	SE	95% CI	p value
MDA T1 ⇔ PT T1	.11	.15	.03	.10 – .20	<.001	.11	.15	.03	.10 – .20	<.001	.11	.15	.03	.10 – .20	<.001
MDA T2 ⇔ PT T2	.09	.15	.03	.09 – .21	<.001	.09	.14	.03	.08 – .21	<.001	.08	.003	.001	.001 – .005	<.001
MDA T1 → MDA T2	.47	.69	.03	.64 – .74	<.001	.46	.68	.03	.63 – .73	<.001	.41	.045	.002	.04 – .05	<.001
PT T1 → PT T2	.41	.40	.02	.37 – .44	<.001	.39	.39	.02	.36 – .43	<.001	.40	.12	.01	.11 – .13	<.001
MDA T1 → PT T2	.06	.01	.002	.004 – .01	<.001	.06	.008	.002	.004 – .01	.001**	.06	.002	.001	.00004 – .004	.001
PT T1 → MDA T2	.06	.66	.20	.28 – 1.05	<.001	.06	.63	.20	.25 – 1.02	.001	.08	.08	.02	.05 – .11	<.001
	χ^2 = 0, Degrees of freedom = 0, p = –, CFI = 1.0, RMSEA = 0 (saturated model)					χ^2 = 77.839, Degrees of freedom = 10, p < .001, CFI = .951, RMSEA = .046					χ^2 = 77.924, Degrees of freedom = 10, p < .001, CFI = .945, RMSEA = .046				

Abbreviations: MDA, maternal depressive/anxious symptoms; PT, presence of tics; β, standardized coefficient; B, nonstandardized coefficient; SE, standard error; 95% CI, 95% confidence interval; CFI, Confirmatory Fit Index; RMSEA, Root Mean Square Error of Approximation.

T1, 10 years of age; T2, 12 years of age.

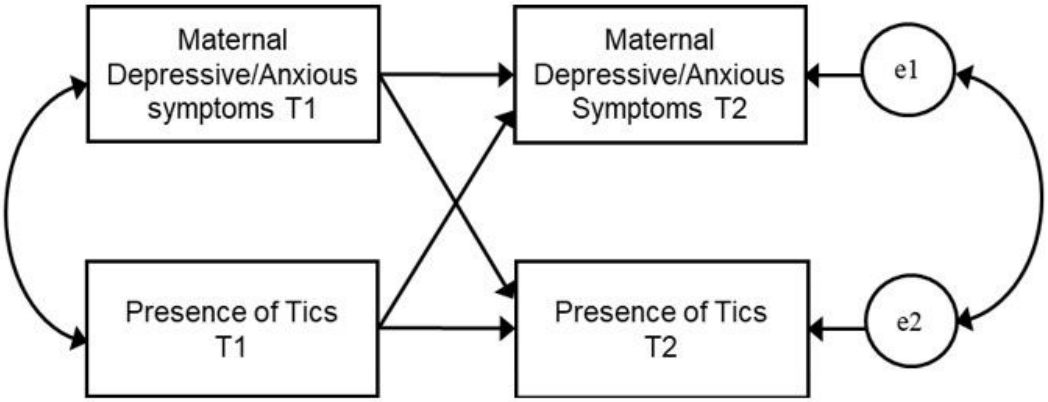
Table 3 Analysis with narrower definition of tics: relationships between maternal depressive/anxious symptoms and children's tics (N = 3,171)

Path	Unadjusted model					Adjusted model					logarithmically transformed model				
	β	B	SE	95% CI	p value	β	B	SE	95% CI	p value	β	B	SE	95% CI	p value
MDA T1 ⇔ PT T1	.08	.09	.02	.05 - .13	<.001***	.08	.09	.02	.05 - .13	<.001***	.08	.09	.02	.05 - .13	<.001***
MDA T2 ⇔ PT T2	.07	.09	.03	.04 - .14	<.001***	.07	.09	.03	.04 - .14	<.001***	.06	.002	.001	.00004 - .004	.001**
MDA T1 → MDA T2	.47	.69	.03	.64 - .74	<.001***	.46	.68	.03	.64 - .73	<.001***	.41	.05	.002	.04 - .05	<.001***
PT T1 → PT T2	.34	.32	.02	.29 - .36	<.001***	.34	.32	.02	.28 - .35	<.001***	.34	.10	.01	.09 - .10	<.001***
MDA T1 → PT T2	.05	.01	.002	.001 - .01	.005**	.05	.005	.002	.001 - .01	.008**	.05	.001	.001	.0003 - .002	.010*
PT T1 → MDA T2	.06	.85	.24	.37 - 1.33	<.001***	.06	.82	.24	.34 - 1.30	<.001***	.07	.07	.02	.04 - .11	<.001***
	χ^2 = 0, Degrees of freedom = 0, p = , CFI = 1.0, RMSEA = 0 (saturated model)					χ^2 = 77.840, Degrees of freedom = 10, p< .001, CFI = .943, RMSEA = .046					χ^2 = 77.935, Degrees of freedom = 10, p < .001, CFI = .934, RMSEA = .046				

Abbreviations: MDA, maternal depressive/anxious symptoms; PT, presence of tics; β, standardized coefficient; B, nonstandardized coefficient; SE, standard error; 95% CI, 95% confidence interval; CFI, Confirmatory Fit Index; RMSEA, Root Mean Square Error of Approximation.

T1, 10 years of age; T2, 12 years of age.

Figures



Abbreviations: e, error variable.

T1 = 10 years of age; T2 = 12 years of age.

Cross-lagged model of the relationships between maternal depressive/anxious symptoms and children's tics in the population-based adolescent sample. Paths from covariates are omitted from the figure.

Figure 1

Cross-lagged models of relationships between maternal depressive/anxious symptoms and children's tics