ORIGINAL ARTICLE

Etiological and Clinical Features of Childhood Psychotic Symptoms

Results From a Birth Cohort

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Context: It has been reported that childhood psychotic symptoms are common in the general population and may signal neurodevelopmental processes that lead to schizophrenia. However, it is not clear whether these symptoms are associated with the same extensive risk factors established for adult schizophrenia.

Objective: To examine the construct validity of children's self-reported psychotic symptoms by testing whether these symptoms share the risk factors and clinical features of adult schizophrenia.

Design: Prospective, longitudinal cohort study of a nationally representative birth cohort in Great Britain.

Participants: A total of 2232 twelve-year-old children followed up since age 5 years (retention, 96%).

Main Outcome Measure: Children's self-reported hallucinations and delusions.

Results: Children's psychotic symptoms are familial and heritable and are associated with social risk factors (eg, urbanicity); cognitive impairments at age 5; home-rearing risk factors (eg, maternal expressed emotion); behavioral, emotional, and educational problems at age 5; and comorbid conditions, including self-harm.

Conclusions: The results provide a comprehensive picture of the construct validity of children's self-reported psychotic symptoms. For researchers, the findings indicate that children who have psychotic symptoms can be recruited for neuroscience research to determine the pathogenesis of schizophrenia. For clinicians, the findings indicate that psychotic symptoms in childhood are often a marker of an impaired developmental process and should be actively assessed.

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WHAT DOES IT MEAN when a child reports experiencing hallucinations or delusions? Increasing interest in this question has been stimulated by reports that hallucinations and delusions occur among children in the community who do not have childhood schizophrenia, that preadolescent children are able to self-report these symptoms, and that groups of such children followed up to adulthood have an elevated prevalence of diagnosed psychotic illness.[1-6] However, the clinical and theoretical significance of their symptoms is not yet clear. From a clinical perspective, it is important to know whether these children are typically characterized by particular risk contexts or clinical features that ought to be a focus of treatment. From a theoretical perspective, it is important to know how the phenomenon of childhood psychotic symptoms fits into the field's current understanding of the origins of schizophrenia and whether children with such symptoms ought to be a focus of etiological research. Thus, we undertook a study to test whether children reporting hallucinations or delusions share the same risk correlates as adults who meet full diagnostic criteria for schizophrenia.

Two important literatures are relevant to determining the meaning of childhood hallucinations and delusions: the literature testing the neurodevelopmental theory of schizophrenia and the literature documenting the presence of psychotic symptoms in the population.

The neurodevelopmental theory of schizophrenia is relevant because it has directed scientific attention to the origins of schizophrenia in early life, many years before the illness can be diagnosed.[7] Evi-

dence from different methodological perspectives documents that individuals who later develop schizophrenia exhibited neurodevelopmental deficits as children.[7] Abnormalities in behavioral, emotional, social, cognitive, and motor development and in neuroanatomy have been reported.[8-10] These deficits are thought to signal the starting point of a risk pathway in which the endpoint is a nonaffective psychotic disorder, depending on genetic, perinatal, and environmental inputs.[9,11] However, the neurodevelopmental theory has not emphasized the emergence during childhood of positive symptoms, such as hallucinations or delusions, and it is unknown whether or how such symptoms should be incorporated into the theory alongside other childhood neurodevelopmental risks.

The dimensional model of schizophrenia is relevant because it has directed scientific attention to the existence of psychotic symptoms in the general population, below the threshold for diagnosis of the illness.[12] Subdiagnostic symptoms are common in the general population of adults,[13-15] and evidence suggests that such symptoms are associated with the same genetic and nongenetic risk factors as the clinical disorder.[15-17] Subdiagnostic symptoms are thought to signal the mild end of a risk continuum for which schizophrenia or psychotic disorder is the extreme point.[15,17] As in neurodevelopmental theory, progression from symptoms to clinical disorder is not necessarily inevitable and likely depends on inherited susceptibility and exposure to environmental risks during development.[15] However, the dimensional model has focused on symptoms during adulthood and has not emphasized the existence of symptoms during childhood. It is unknown whether or how such childhood symptoms should be incorporated into dimensional approaches.

These 2 relevant literatures suggested to us the possibility that psychotic symptoms in childhood signal neurodevelopmental processes that are already known to lead to schizophrenia and that childhood symptoms are part of the dimension of schizophrenia risk. Our research team previously reported that members of the Dunedin (New Zealand) Longitudinal Study birth cohort who self-reported psychotic symptoms at age 11 years had an elevated risk of developing schizophreniform disorders by age 26 (odds ratio, 16.4; 95% confidence interval, 3.9-67.8),[1] results which have been subsequently replicated.[3] This finding was consistent with the possibility that childhood psychotic symptoms signal neurodevelopmental processes that increase the risk for schizophrenia onset in adolescence or adulthood. Corroborating this hypothesis, our research team later reported that children in the Dunedin cohort with psychotic symptoms also showed significant impairments during childhood in motor development, language, and intelligence, skills that are often impaired among individuals who develop schizophrenia.[18] Other studies have evaluated individual correlates, including perinatal complications,[19] paternal age,[20] low IQ,[21] childhood trauma,[22] peer victimization,[2] and behavioral problems.[23]

In this study, we extend this previous work by testing the hypothesis that children who report psychotic symptoms are characterized by the same extensive network of risk factors and correlates previously reported in the research literature on adult schizophrenia. We evaluated the occurrence of psychotic symptoms in a nationally representative British twin birth cohort of 2232 twelve-year-olds. Guided by the research literature on schizophrenia,[8,24-27] we tested 7 hypotheses. First, we evaluated whether, like schizophrenia, childhood psychotic symptoms are familial by testing whether children with symptoms were more likely to have mothers with psychotic-spectrum disorders and family members who had been admitted to psychiatric units or who had attempted or completed suicide.[28] Second, we evaluated whether, as with schizophrenia, children's self-reported psychotic symptoms are heritable[29] by using the twin design to estimate the genetic contribution to variation in children's symptoms. Third, we evaluated whether children with psychotic symptoms shared schizophrenia's social risk factors by testing whether these children were more likely to live in an urban environment[30] and come from disadvantaged families.[31] Fourth, we evaluated whether children with psychotic symptoms shared schizophrenia's neurodevelopmental risk factors by testing whether these children had older fathers,[32] were born during winter or spring,[33] had lower birth weight,[34,35] suffered perinatal complications,[36] or had cognitive characteristics including low IQ,[37] executive functioning deficits,[38,39] and impaired theory of mind.[40,41] Fifth, we evaluated whether children with psychotic symptoms shared schizophrenia's home-rearing risk factors by testing whether these children had mothers with high expressed emotion,[42] lived in chaotic households,[27,43] or had been victims of physical maltreatment.[44-46] Sixth, we evaluated schizophrenia's early-childhood behavioral risk factors[8] by testing whether 12-year-olds with psychotic symptoms had, as 5-year-olds, shown externalizing and internalizing problems, social isolation,[10] or educational problems.[10] Seventh, we evaluated schizophrenia's comorbid conditions by testing whether children with psychotic symptoms self-reported more concurrent antisocial behavior,[24] depression and anxiety symptoms,[24] and tobacco use[47] and cannabis use[48] and whether they were more likely to harm themselves.[49]

METHODS

PARTICIPANTS

Participants were members of the Environmental Risk (E-Risk) Longitudinal Twin Study, which tracks the development of a nationally representative birth cohort of 2232 British children. The sample was drawn from a larger birth registry of twins born in England and Wales from 1994 through 1995.[50] Details about the sample have been reported previously,[51] including in this journal.[52] Briefly, the E-Risk sample was constructed from 1999 through 2000, when 1116 families with same-sex 5-year-old twins (93% of those eligible) participated in home-visit assessments. Families were recruited to represent the United Kingdom population of families with newborns in the 1990s, based on residential location throughout England and Wales and mother's age (ie, older mothers having twins via assisted reproduction were underselected and teen-

Table 1. Frequency of Children's Self-reported Psychotic Symptoms[a]

Psychotic Symptom	No. (%) of 2127 Children: Probable Symptom	Definite Symptom
Hallucinations		
Have you heard voices that other people cannot hear?	169 (7.9)	90 (4.2)
Have you ever seen something or someone that other people could not see?	168 (7.9)	42 (2.0)
Delusions		
Have you ever thought you were being followed or spied on?	54 (2.5)	15 (0.7)
Have you ever felt like you were under the control of some special power?	41 (1.9)	16 (0.8)
Have you ever known what another person was thinking, even though that person wasn't speaking, like read their mind?	14 (0.7)	5 (0.2)
Have you ever believed that you were sent special messages through television or radio?	26 (1.2)	3 (0.1)
Have other people ever read your thoughts?	9 (0.4)	0

[a] Symptoms are not mutually exclusive.

aged mothers with twins were overselected). Follow-up home visits were conducted when the children were aged 7 years (98% participation), 10 years (96% participation), and, most recently, 12 years (96% participation). The sample includes 55% monozygotic and 45% dizygotic twin pairs. Sex is evenly distributed within zygosity (49% were boys). Parents gave informed consent and children gave assent. Confidentiality was preserved, and the child's general practitioner was notified only when a mother reported her child was a risk to self or others. The Maudsley Hospital Ethics Committee approved each phase of the study.

EVALUATING CHILDREN'S PSYCHOTIC SYMPTOMS

At age 12, children were assessed for psychotic symptoms in a private interview conducted by mental health trainees or professionals. Interviewers had no prior knowledge about the child. Different staff members interviewed the child's parents. We investigated 7 psychotic symptoms (**Table 1**). Our item choice was guided by the Dunedin Study age-11 interview protocol[1] and a subsequent instrument prepared for the Avon Longitudinal Study of Parents and Children.[2] Our protocol took a conservative approach to designating a child's report as a symptom. First, when a child endorsed any symptom, the interviewer probed using standard prompts designed to discriminate between experiences that were plausibly real (eg, "I was followed by a man after school") vs potential symptoms (eg, "I was followed by an angel who guards my spirit") and wrote down the child's narrative description of the experience. Interviewers coded each experience as "not a symptom" (0), "probable symptom" (1), or "definite symptom" (2). Second, a psychiatrist expert in schizophrenia (M.C.), a psychologist expert in interviewing children (L.A.), and a child and adolescent psychiatrist (G.P.) reviewed all the written narratives to confirm the interviewers' codes (but without consulting other data sources about the child or family). Third, because ours was a sample of twins, experiences limited to the twin relationship (eg, "My twin and I often know what each other are thinking") were coded as "not a symptom."

DISTRIBUTION OF CHILDREN'S PSYCHOTIC SYMPTOMS

Table 1 shows the frequency of children's psychotic symptoms, coded as probable or definite. Auditory and visual hallucinations were the most common symptoms, and mind reading was the least common symptom. Psychotic symptoms were reported by 416 children (19.6%): 291 (13.7%) reported only probable symptoms and 125 (5.9%) reported at least 1 definite symptom. Among children with at least 1 definite psychotic symptom, multiple symptoms were typical: 36 (28.8%) reported multiple definite symptoms and 76 (60.8%) also reported probable symptoms.

DEFINING TARGET GROUPS OF CHILDREN FOR ANALYSIS

To test the heritability of psychotic symptoms, we summed the response codes (0, 1, and 2) across the 7 symptoms for each child. Scores in the sample ranged from 0 to 13 (mean [SD], 0.4 [1.0]). To test the hypotheses about the risk factors and correlates of children's psychotic symptoms, we compared 2 groups of children: those who did not present any definite psychotic symptom (hereafter called the "symptom-absent group"; n = 2002) vs children who presented at least 1 definite psychotic symptom according to the clinical review of narratives (hereafter called the "symptom-present group"; n = 125). One boy in this group had, by age 12 years, received a formal diagnosis of schizophrenia by the family physician and was being treated with antipsychotic medication, according to his mother. Analyses were performed with and without the inclusion of this child, and results did not differ; therefore, we decided to keep him in the sample.

SCHIZOPHRENIA-RELATED RISK FACTORS AND CORRELATES

Table 2 lists the measures used to test each hypothesis about the risk factors and correlates of children's psychotic symptoms. The table provides information about each measure, its source, the age at which it was obtained, and descriptive statistics.

STATISTICAL ANALYSIS

To test the relative magnitude of genetic and environmental influences on psychotic symptoms, we first examined the phenotypic correlation within pairs of monozygotic and dizygotic twins. We then used Mplus statistical software[73] to decompose variance in children's psychotic symptoms into latent genetic (ie, the sum of the average effects of individual alleles at all loci), latent family-wide environmental, and latent child-specific environmental factors.[74]

To test the hypotheses about the risk factors and correlates of children's psychotic symptoms, we conducted logistic and linear regression analyses comparing symptom-absent with symptom-present groups of children. Because each study family contains 2 children, statistical analyses were corrected conservatively for the nonindependence of the twin observations by using tests based on the sandwich or Huber/White variance estimator[75] in Stata statistical software, version 10.[76]

Table 2. Description of the Investigated Risk Factors and Correlates of Children's Psychotic Symptoms

Measure	Respondent	Description of the Measure	Age at Evaluation, y	Sample Distribution[a]
Familiality				
Maternal psychosis-spectrum disorder	Mother	Diagnostic Interview Schedule[53] diagnosis according to *DSM-IV*,[54] evidence of social, occupational, or self-care dysfunction; diagnosis reviewed by a clinician	10	5.5
Admission to psychiatric units	Parents	First- or second-degree relatives who have ever been admitted to a psychiatric unit	12	26.3
Family history of suicide	Parents	First- or second-degree relatives with a positive history of attempted or completed suicide	12	16.4
Social risk factors				
Urban residence	Neighbors	Classification of children's neighborhood as a city or other type of urban setting based on a community-level survey of more than 5600 residents living in the same postcode (ie, street or apartment building) as each E-Risk family	12	50.9
Socioeconomic disadvantage	Parents	Lowest tertile of socioeconomic index, a composite of parental income, education, and occupation[55]	5	33.2
Neurodevelopmental risk factors				
Paternal age, y	Parents	Father's age at child's birth	Birth	31.8 (6.3)
Birth in winter or spring	Parents	Child's date of birth	Birth	49.5
Birth weight[b]	Parents	Absolute values for weight were standardized with reference to birth weight in relation to gestational age of 19 000 twins born in England from 1988 through 1992[56]	Birth	0 (1)
Multiple perinatal complications	Parents	Two or more of the following: high blood pressure, diabetes, preeclampsia, vaginal bleeding, water breaking >11 h before labor, slow infant growth, or rubella during pregnancy	Birth	21.9
IQ[c]	Child	WPPSI Revised[57]; children were administered 2 subtests: Vocabulary and Block Design, and IQ scores were prorated following procedures described by Sattler.[58]	5	100 (15)
Executive functioning[c]	Child	Children were administered 3 executive functions tests: Mazes,[59] a WPPSI subtest; Day-Night,[60] a nonverbal analog of the Stroop task; and Sentence Working Memory, based on the Baddeley model of working memory,[61,62] which requires the child to hold 1 (or more) item in active working memory while processing necessary information for the generation of the second (and so forth) item; children's scores on the 3 tests were averaged and standardized.	5	100 (15)
Theory of mind[c]	Child	Battery of Theory of Mind tasks,[63] administered in a set order of increasing difficulty. The test questions tapped children's ability to attribute a first-order false belief to a story character, to make inferences from an attributed false belief, and to attribute a second-order false belief to a story character; children's responses were summed and standardized.	5	100 (15)

(continued)

RESULTS

CHARACTERISTICS OF CHILDHOOD PSYCHOTIC SYMPTOMS

Heritable

The within-pair correlation for the scale measuring psychotic symptoms was 0.41 among monozygotic twins and 0.22 among dizygotic twins. The fact that the correlation was greater among monozygotic vs dizygotic twins suggests a genetic influence for this phenotype. Specifically, genetic effects accounted for 43% of the variance (95% confidence interval, 34%-52%), and child-specific environmental factors and error accounted for 57% (51%-64%).

Familial

Table 3 presents the risk factors and correlates for symptom-absent vs symptom-present children. Children with psychotic symptoms were more likely than children without psychotic symptoms to have mothers with psychosis-spectrum disorders as well as family members who had been admitted to psychiatric units and who had attempted or completed suicide (Table 3).

Schizophrenia-Related Risk Factors

With regard to social risk factors, children with psychotic symptoms were more likely than children without psychotic symptoms to live in an urban environ-

Table 2. Description of the Investigated Risk Factors and Correlates of Children's Psychotic Symptoms (continued)

Measure	Respondent	Description of the Measure	Age at Evaluation, y	Sample Distribution[a]
Home-rearing risk factors				
Maternal expressed emotion[b]	Mother, coded by independent raters	Assessed using a 5-min speech sample eliciting expressed emotion from the mother; speech samples were audiotaped and coded by 2 independent raters. Maternal negativity (coded on a 6-point scale) is a global measure of the whole speech sample, indexing negativism expressed in the interview about the child. Maternal warmth (6-point scale) is a global measure of the whole speech sample, indexing warmth expressed in the interview about the child.[64]	10	Negativity, 0 (1); warmth, 0 (1)
Household chaos[b]	Mother and child	Items indicating extent of routine, privacy, predictability, and organization in the home[43]	12	0 (1)
Physical maltreatment	Mother, coded by clinicians	Interview using the reliable standardized clinical protocol from the Multi-Site Child Development Project, a protocol designed to enhance mothers' comfort with reporting valid child maltreatment information while also meeting researchers' legal and ethical responsibilities for reporting; examples included: victim of adjudicated assault by a teenaged sibling, punished by being burned with matches, injured (eg, fractures or dislocations) from neglectful or abusive parental care, and/or formally registered with a child protection team for physical abuse.[65,66]	5, 7, 10, and 12	5.6
Behavioral, emotional, and educational risk factors at age 5 y				
Antisocial behavior[b]	Mother, teacher, and child	CBCL/ TRF Aggression and Delinquency subscales[67]; Berkeley Puppet Interview[68,69] for children	5	0 (1)
ADHD symptoms[b]	Mother and teacher	*DSM-IV* Attention-Deficit/Hyperactivity Disorder items[54,70]	5	0 (1)
Internalizing problems[b]	Mother and teacher	CBCL/TRF Anxiety, Withdrawn, and Somatic subscales[67]	5	0 (1)
Social isolation[d]	Mother and teacher	Positive endorsement of CBCL/TRF[67] items (eg, would rather be alone than with others; not liked by other children)	5	Mothers, 5.6; teachers, 2.9
Educational problems	Teacher	1 or More of the following: referred to special educational service, works less hard than other students, and is learning less than other students[67]	5	38
Comorbid behavioral and emotional problems at age 12 y				
Antisocial behavior[b]	Child	*DSM-IV* Conduct Disorder items[54]	12	0 (1)
Depressive symptoms[b]	Child	Children's Depression Inventory[71]	12	0 (1)
Anxiety symptoms[b]	Child	Multidimensional Anxiety Scale for Children[72]	12	0 (1)
Tobacco use or experimentation	Child	"Have you ever tried smoking a cigarette?"	12	12
Cannabis use or experimentation	Child	"Have you ever tried any hash or cannabis?"	12	1
Self-harm/suicidal behavior	Mother	Deliberately harms self or attempts suicide	12	3

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; CBCL, Child Behavior Checklist; E-Risk, Environmental Risk Longitudinal Twin Study; TRF, Teacher Report Form; WPPSI, Wechsler Preschool and Primary Scale of Intelligence.

[a] Data are given as mean (SD) or the percentage of participants.

[b] Values are standardized: mean (SD), 0 (1).

[c] Values are standardized: mean (SD), 100 (15).

[d] The social isolation items in the withdrawn subscale of the CBCL/TRF were analyzed separately.

ment and to come from disadvantaged families. With regard to neurodevelopmental risk factors, children with psychotic symptoms had lower birth weights for their gestational age and were slightly more likely to have multiple perinatal complications ($P = .09$). They exhibited significantly lower IQs, slightly greater executive deficits ($P = .07$), and impaired theory of mind. With regard to home-rearing risk factors, children with psychotic symptoms were reared by mothers who had more negative expressed emotion toward them (but not less warmth), lived in more chaotic households (according to both parent and child reports), and were more likely to have been physically maltreated (Table 3).

Early Childhood Behavioral Risk Factors

Twelve-year-olds with psychotic symptoms had more externalizing behavior problems (antisocial, inattentive, and hyperactive behaviors) as 5-year-olds, according to all informants. According to maternal reports, 12-year-olds with psychotic symptoms also had more internalizing problems at age 5, but this finding was only a trend accord-

Table 3. Schizophrenia-Related Risk Factors and Correlates Observed Among Symptom-Present vs Symptom-Absent Children

	Psychotic Symptoms at Age 12 y[a]			
	Symptom-Absent Group (n=2002)	Symptom-Present Group (n=125)	OR (95% CI) or ß (SE)	*P* Value
Demographic characteristics				
Boys	963 (48.1)	71 (56.8)	1.4 (0.9-2.1)	.09
Ethnic minority	201 (10.0)	8 (6.4)	0.6 (0.3-1.5)	.28
Familiality				
Maternal psychosis-spectrum disorder	99 (5.1)	14 (11.7)	2.5 (1.2-4.9)	.01
Family members admitted to psychiatric units	509 (25.5)	47 (37.9)	1.8 (1.2-2.7)	.007
Family members with suicide attempts	312 (15.7)	36 (29.0)	2.2 (1.4-3.5)	.001
Social risk factors				
Urban residence	987 (51.1)	79 (64.8)	1.8 (1.2-2.7)	.009
Socioeconomic disadvantage	658 (32.9)	53 (42.4)	1.5 (1.0-2.3)	.049
Neurodevelopmental risk factors				
Paternal age at birth, mean (SD), y	31.9 (6.3)	31.8 (6.9)	0.03 (0.80)	.97
Birth in winter or spring	933 (49.4)	66 (55.0)	1.3 (0.8-1.9)	.28
Birth weight, mean (SD) *z* score	0.02 (1.0)	−0.19 (0.98)	−0.21 (0.10)	.04
Multiple perinatal complications	353 (21.5)	31 (29.5)	1.5 (0.9-2.5)	.09
IQ, mean (SD)	100.5 (14.9)	93.0 (14.6)	−7.51 (1.43)	<.001
Executive functioning score, mean (SD)	100.2 (14.8)	97.5 (15.8)	−2.65 (1.46)	.07
Theory of mind score, mean (SD)	100.3 (15.0)	95.6 (13.8)	−4.74 (1.32)	<.001
Home-rearing risk factors				
Maternal expressed emotion score				
Negativity, mean (SD)	−0.01 (1.0)	0.24 (1.0)	0.24 (0.10)	.02
Warmth, mean (SD)	0 (0.9)	−0.02 (1.1)	−0.02 (0.10)	.84
Household chaos score, mean (SD)				
Maternal report	−0.02 (1.0)	0.26 (1.1)	0.27 (0.11)	.02
Child report	−0.03 (1.0)	0.53 (1.1)	0.56 (0.10)	<.001
Physical maltreatment	101 (5.0)	20 (16.0)	3.6 (2.0-6.4)	<.001
Behavioral, emotional, and educational risk factors at age 5 y				
Antisocial behavior, mean (SD) *z* score				
Maternal report	−0.01 (0.99)	0.22 (1.12)	0.24 (0.10)	.02
Teacher report	−0.01 (0.99)	0.31 (1.19)	0.33 (0.11)	.005
Child report	−0.02 (0.99)	0.29 (1.10)	0.31 (0.12)	.01
ADHD Symptoms, mean (SD) *z* score				
Maternal report	−0.02 (0.99)	0.28 (1.03)	0.31 (0.09)	.001
Teacher report	−0.02 (0.99)	0.32 (1.15)	0.33 (0.12)	.006
Internalizing problems, mean (SD) *z* score				
Maternal report	−0.01 (0.98)	0.29 (1.17)	0.31 (0.11)	.006
Teacher report	−0.01 (0.99)	0.16 (1.14)	0.17 (0.11)	.12
Social isolation				
Maternal report	106 (5.3)	12 (9.6)	1.9 (1.0-3.5)	.04
Teacher report	52 (2.8)	7 (6.0)	2.3 (0.9-5.5)	.07
Educational problems	683 (36.2)	70 (59.8)	2.6 (1.8-3.9)	<.001
Comorbid behavioral and emotional problems at age 12 y				
Antisocial behavior, mean (SD) *z* score	−0.03 (0.97)	0.52 (1.26)	0.55 (0.12)	<.001
Depressive symptoms, mean (SD) *z* score	−0.06 (0.90)	0.85 (1.75)	0.90 (0.16)	<.001
Anxiety symptoms, mean (SD) *z* score	−0.04 (0.99)	0.58 (1.0)	0.62 (0.10)	<.001
Tobacco use or experimentation	219 (11.1)	29 (25.0)	2.7 (1.7-4.2)	<.001
Cannabis use or experimentation	19 (1.0)	2 (1.7)	1.8 (0.4-7.7)	.45
Self-harm/suicidal behavior	51 (2.6)	11 (8.8)	3.7 (1.8-7.5)	<.001

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; ß, regression coefficient; CI, confidence interval; OR, odds ratio.
[a] Data are given as number (percentage) of participants unless otherwise indicated.

ing to teacher reports. Finally, 12-year-olds with psychotic symptoms were more likely to have been socially isolated at age 5, according to mothers and, marginally so, teachers, and to have had educational problems at age 5 (Table 3).

Concurrent Behavioral and Emotional Problems

Children with psychotic symptoms reported that they engaged in more antisocial behavior and experienced more symptoms of depression and anxiety than children without psychotic symptoms. Children with psychotic symptoms were also more likely to have used tobacco but not cannabis. Finally, according to their mothers, children with psychotic symptoms were more likely to have engaged in self-harm (Table 3). According to maternal reports, the self-harm behaviors included cutting with razors, beating head against the wall, and attempted hanging. Two children made suicide attempts resulting in hospitalization, in which the children followed voices of com-

mand. (Although not included in our measure of self-harm behaviors, one child attempted to cut his mother with a knife following a voice of command.) There were no completed suicides.

ADDITIONAL ANALYSES

We conducted 3 sets of additional analyses. First, because we included children with only probable symptoms in the symptom-absent group, we investigated how the distribution of risk factors and correlates in these children compares with the distribution of risk factors and correlates in children with definite symptoms and no symptoms. Children with only probable symptoms generally had intermediate scores, between those of children with no symptoms and children with definite symptoms. Because the nature of their self-reported symptoms was more ambiguous and clinically uncertain, including them in the symptom-absent group is a conservative approach.

Second, because it is conceivable that the risk factors and correlates investigated are not specific to schizophrenia, we investigated their association with childhood psychotic symptoms controlling for concurrent depressive symptoms. Only 4 of 25 correlates were no longer independently associated with psychotic symptoms at a P value of $\leq$.05: socioeconomic disadvantage (P=.09), mother's report of antisocial behavior at age 5 (P=.06), and mother's (P=.14) and teacher's (P=.15) report of social isolation at age 5. The effect of all 21 other risk factors and correlates remained statistically significant, including self-harm (odds ratio, 2.0; 95% confidence interval, 1.0-3.9; P=.04).

Third, because it is conceivable that psychotic symptoms are associated with neurological disorders, and in some cases may be caused by them, we investigated whether migraine, epilepsy, seizures, or other neurological disorders were more common in the symptom-present group. The occurrence of childhood psychotic symptoms was not associated with these neurological disorders in our sample (odds ratio, 1.8; 95% confidence interval, 0.7-4.5; P=.23). Five children in the symptom-present group (4.0%) and 46 in the symptom-absent group (2.3%) presented these conditions.

COMMENT

We examined psychotic symptoms and their risk factors in a birth cohort of 12-year-old twins ascertained from the general population. Results confirmed that a significant minority of 12-year-olds in the community self-report hallucinations and delusions. In addition, these symptoms are associated with many of the same risk factors and correlates as adult schizophrenia, including genetic, social, neurodevelopmental, home-rearing, and behavioral risks.

Our findings suggest that the continuum model of psychosis[15] may apply to preadolescents, as well as to the adults for which it was developed. The prevalence of psychotic symptoms in our birth cohort of 12-year-olds was 5.9%, which is similar to the reported prevalence of childhood psychotic symptoms in other contemporary community samples of adolescents between ages 11 and 17 years[4-6,21,77] (although prevalence estimates vary as the measures and numbers of questions used to assess psychotic symptoms vary). Furthermore, hallucinations were the most frequent psychotic symptom reported, a pattern previously reported in community[21,22] and clinical samples.[78,79] This estimated prevalence of psychotic symptoms in child populations markedly exceeds the estimated prevalence of early-onset schizophrenia,[80] just as the prevalence of psychotic symptoms in adult populations markedly exceeds the prevalence of adult psychotic disorders.[15,24] The presence of psychotic symptoms in preadolescence adds support to the hypothesis that symptoms may signal a longstanding trait diathesis, which in some but not all individuals converts to clinical disorder during adolescence or adulthood.

Our findings also suggest that the neurodevelopmental model of schizophrenia[9,11] is useful for understanding the pathogenesis of childhood psychotic symptoms. As with adult schizophrenia, childhood psychotic symptoms were familial and heritable, associated with early impairments in cognitive functioning, and linked to premorbid behavioral, emotional, and educational problems. (Childhood psychotic symptoms were not associated with ethnicity.) Three findings, in particular, warrant comment.

To our knowledge, this is the first study to evaluate the familiality and heritability of psychotic symptoms in a representative sample of children from the general population. Consistent with studies of schizophrenia,[81] we found that childhood hallucinations and delusions are influenced by genetic and environmental factors that are unique in the life of each sibling (and measurement error). Our twin data yielded a moderate coefficient of heritability (43%) that is similar to heritability estimates for adult psychotic symptoms and schizotypy[82,83] and somewhat lower than heritability estimates for schizophrenia,[29] suggesting that individuals with symptoms that progress to clinical disorder are influenced by a stronger genetic load. Alternatively, it is possible that the heritability of psychotic symptoms, assessed here at age 12, may increase with age as does the heritability of some other psychiatric phenotypes.[84] The nonsignificant quantitative estimate of environmental factors shared by siblings in a family is also consistent with previous studies of genetic and environmental influences on schizotypy[85] and schizophrenia.[86] Our study revealed that, like schizophrenia itself, childhood psychotic symptoms are associated with measured social and home-rearing risk factors that might be expected to have similar consequences for siblings growing up together (eg, urban residence, socioeconomic disadvantage, household chaos). How is it possible that measured family-environment risks predicted psychotic symptoms, whereas the twin model estimated no family-environment effect on psychotic symptoms? Whether such risk factors lead to childhood psychotic symptoms may depend on each child's genetic vulnerabilities.[87] When influences of siblings' shared environments interact with genetic vulnerability, these effects are included in the genetic component of twin models.

Second, we observed several cognitive deficits among children as young as 5 years who later developed psy-

chotic symptoms. Impaired theory of mind at age 5 characterized children with psychotic symptoms, corroborating the hypothesis that a deficit in the capacity to infer and represent others' mental states is a trait of individuals with psychotic disorders.[40] Moreover, the IQ deficit that we found among children with psychotic symptoms at age 5 is the same size as the IQ deficit observed among individuals with schizophrenia before illness onset: approximately one-half of a standard deviation.[37] Of interest, our composite measure of executive functions at age 5 (planning ability, inhibitory control, and working memory) was only weakly, and not significantly, associated with psychotic symptoms at age 12. It is possible that age 5 years may be too young to detect executive functioning deficits in relation to psychosis; recent research suggests that deficits in executive functions may emerge in later childhood or early adolescence.[88] Although the neurodevelopmental theory of schizophrenia has not emphasized childhood hallucinations and delusions, our findings suggest that such symptoms should be incorporated into the theory. Neurodevelopmental risk factors such as low IQ are common in the population and are associated with other mental disorders in adulthood.[89] The key question is why only a few children with neurodevelopmental deficits and lower cognitive reserve eventually progress to adult schizophrenia, whereas most do not. Neurodevelopmental risks in early childhood affect many children; a smaller subset of children with neurodevelopmental risk go on to experience psychotic symptoms in preadolescence, and a smaller subset of these preadolescents with psychotic symptoms go on to develop schizophrenia. Thus, the psychotic symptoms we have studied may help to identify a key turning point in the canalization from neurodevelopmental risk into clinical disorder and to elucidate the nature of the association between low childhood IQ and schizophrenia.

Third, we found that 12-year-olds with psychotic symptoms had significantly more behavioral, emotional, and educational problems by age 5. Moreover, when children manifested psychotic symptoms as 12-year-olds, they also had significantly more antisocial behavior, depression symptoms, anxiety symptoms, and self-harm. These findings are consistent with reports of higher rates of psychiatric comorbidity in clinical samples of children with psychosis.[78,79] These findings are also consistent with prospective[3,10] and retrospective[90,91] studies showing that adults with schizophrenia had elevated rates of aggression, anxiety, depression, and social and educational problems as children. Strikingly, like young people with clinical psychosis[79] and adults with schizophrenia,[49] children with psychotic symptoms were more likely to engage in self-harm or suicidal behavior (independent of depression). Given that children's self-harm was reported by their mothers in our study, not the children themselves, and that children can conceal self-harm from parents, the association between psychotic symptoms and self-harm may be underestimated here.

Our study has limitations. First, we were unable to evaluate the role of all important schizophrenia risk factors, such as delayed motor development. Second, we did not examine how the various schizophrenia risk factors were themselves correlated and whether these risk factors had independent or overlapping associations with children's psychotic symptoms. Rather, the goal of this study was to assess the construct validity of children's self-reported psychotic symptoms by evaluating the nomological network surrounding these symptoms. Such an evaluation of construct validity requires testing hypothesized relations between children's symptoms and risk factors and correlates for which there are theoretical grounds to expect significant associations.[92] To our knowledge, the results of this study provide the most comprehensive picture to date of the clinical and theoretical significance of children's self-reported psychotic symptoms. Third, we studied a cohort of twins, who may not represent singletons. However, prior comparisons have found no twin to singleton differences in behavior problems, IQ, or personality traits.[93-98] Nevertheless, replication of findings in studies of singletons is important. Fourth, we evaluated only a set of 7 positive symptoms. A more extensive assessment, including negative symptoms, may be desirable to identify risk factors and correlates that may be specific to particular symptom dimensions.

Our study also has strengths. We studied a nationally representative sample, followed up to age 12 years with 96% retention. Psychotic symptoms were assessed by well-trained mental health interviewers in a private interview with each child, and reports were subsequently reviewed by expert clinicians. Risk factors were assessed prospectively through multiple informants or formal testing of the child using measures with documented validity, independent of the assessment of psychotic symptoms. Incidentally, only 2% of the children with psychotic symptoms had used cannabis and only 4% had neurological disorders, indicating that the psychotic symptoms reported were not the result of these causes.

Our results have implications for research and clinical practice. For researchers, the findings indicate that children in the community who have psychotic symptoms can be recruited for neuroscience research into the pathogenesis of schizophrenia,[99] years before the prodrome and long before the neurobiological picture is muddied by medications, substance abuse, and the rapid changes in brain development that characterize adolescence.[100] For example, a neuroimaging paradigm recently used with ultra–high-risk and first-episode research cases, aged 14 to 30 years, could be extended to children assessed here.[101] Because the risk factors and correlates investigated are not specific to schizophrenia, it is possible that childhood psychotic symptoms are developmental precursors not only of schizophrenia but also of other disorders. Longitudinal evaluation of individuals throughout adulthood can address this issue. Because, as our findings show, psychotic symptoms generally occurred in the context of other disorders, including attention-deficit/hyperactivity disorder, antisocial conduct, depression, and anxiety, it is feasible to screen pediatric psychiatric patients to identify children with hallucinations and delusions. It is our impression, based on experience with the E-Risk and Dunedin cohorts, that ages 11 to 12 years are an ideal window for obtaining self-reports of covert experiences such as hallucinations and

delusions in a clinical interview. On the one hand, preadolescents are cognitively mature enough to understand what the questions are about. Therefore, they can provide valid self-reports of hallucinations and delusions. On the other hand, they have not yet learned by sad experience that they must conceal their psychotic symptoms to avoid stigma, ridicule, and rejection by others. Thus, preadolescents are willing to share frank self-reports with a sensitive interviewer.

For clinicians, the findings indicate that psychotic symptoms in childhood are often a marker of an impaired developmental process and should be actively assessed. Psychotic symptoms generally occurred in the context of other childhood psychiatric problems, indicating that it is worthwhile to ask all preadolescent psychiatric patients about hallucinations and delusions. Even if the psychotic symptoms are not themselves impairing, they are associated with important risk factors, such as chaotic household, maternal negativity, and physical maltreatment, and with behavioral problems, such as early tobacco use and self-harm, that should be a focus of attention. Whether interventions focused on childhood psychotic symptoms will prove necessary, feasible, or cost-effective is an important and unanswered question.

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