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Psychotic-like experiences from adolescence to adulthood: A longitudinal study

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ABSTRACT

Psychotic-like experiences (PLEs), such as delusions and hallucinations, are regarded to occur along a spectrum and to be present also in non-help-seeking individuals from the general population. However, it remains unclear whether the occurrence of PLEs is a unique risk factor for future PLEs or a symptom of general psychopathology. In this study, we investigated whether PLEs during adolescence predict future PLEs in adulthood. A community-based cohort of 1146 young adolescents (mean age, 14.38 years) were assessed and then reassessed 6 years later (mean age, 20.15 years). Participants reported PLEs experienced in the past year, as well as symptoms of depression, anxiety, attention-deficit/hyperactivity disorder, and conduct problems. We adjusted the analysis for other forms of psychopathology and sex differences. Participants who reported PLEs in adulthood had higher ratings for all preceding and co-occurring symptoms of psychopathology. In the adjusted logistic regression model, having PLEs and, to a smaller degree, anxiety during adolescence predicted PLEs in early adulthood. The association between baseline and future PLEs did not differ between males and females, although females were more likely to report PLEs during adolescence. Participants with persistent PLEs reported more hallucinations during adolescence than those with transient symptoms. Our findings suggest that the early occurrence of PLEs is an important and independent predictor of future PLEs and should be monitored to identify individuals with a high risk of future psychopathology and to enable early interventions.

1. Introduction

Psychotic-like experiences (PLEs) have been described as psychotic symptoms in the absence of illness, psychotic symptoms in non-clinical populations, and as a subclinical psychosis phenotype (Hinterbuchinger and Mossaheb, 2021; Kelleher and Cannon, 2011; Lee et al., 2016). Symptoms of PLEs include visual and auditory hallucinations, paranoid delusions, bizarre behavior, and beliefs such as someone else is controlling one's body or possesses special powers (Laurens et al., 2007; Lee et al., 2016). As PLEs lies between the normal and pathological experiences, and since a dimensional approach toward psychosis is assumed, there is no clear consensus on the definition of PLEs and how these differs from e.g., psychotic disorders (Lee et al., 2016). In a review, evaluating terminology and assessment tools of psychosis, PLEs were defined as often transient and mild symptoms found in the general population and in those at-risk (Seiler et al., 2020). In contrast, neighboring terms such as attenuated psychotic symptoms were to a higher degree than PLEs associated with distress, risk, and help-seeking behavior, whereas prodromal psychotic symptoms, psychotic symptomatology and psychotic symptoms were associated with a closer proximity to a psychotic threshold (Seiler et al., 2020).

PLEs are more common in childhood and their prevalence decreases with age. The prevalence of PLEs is estimated as 17 % in school-aged children, 7.5 % in teenagers (Kelleher et al., 2012a), and around 5 % in adults (van Os et al., 2009). It is not known why PLEs are persistent in some people but transitory in others (Kalman et al., 2019). It has been hypothesized that transitory PLEs are a part of normative development, whereas persistent PLEs are associated with psychopathology (Laurens et al., 2012). The occurrence of PLEs is also considered to be a risk factor for future psychosis. For example, in one study, children with delusional

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beliefs and hallucinatory experiences at age 11 years had a high risk of a schizophreniform diagnosis at age 26 years (Poulton et al., 2000). A systematic review that included both adolescent and adult samples showed that the yearly risk of developing clinical psychosis was 3.5 times higher in people with previous subthreshold self-reported psychotic experiences (Kaymaz et al., 2012). A recent systematic review and meta-analysis reported a fourfold increased risk for psychosis in adults who experienced PLEs during childhood (Healy et al., 2019). Another systematic review and meta-analysis reported that the probability of persistence was strongly related to the rate of PLEs at the baseline and that about 20 % of people who report PLEs continue to have PLEs and 7.4 % develop a psychotic disorder (Linscott and van Os, 2013).

Although research has focused primarily on PLEs as a risk factor for psychosis, recent studies have shown that PLEs are also associated with a broad range of other psychopathologies (Bourgin et al., 2020), including concentration difficulties, affective and behavioral problems (Kelleher et al., 2012b), social phobia and obsessive–compulsive disorder (Rössler et al., 2011), substance use and suicide (Cederlöf et al., 2017), autism spectrum disorder (Jutla et al., 2021), lower intellectual ability (Johns et al., 2004), lower working memory capacity (Ziermans, 2013), reduced global functioning, and posttraumatic stress disorder (Calkins et al., 2014). A previous study of a sample of adolescents by our research group showed that PLEs predicted symptoms of anxiety, depression, and conduct disorders 3 years later (Isaksson et al., 2020).

It remains to be decided whether PLEs should be regarded as a unique risk factor for an increased risk of psychotic symptoms in adulthood or whether PLEs lose their importance once comorbidities are accounted for. It has been argued that PLEs can be regarded as a transdiagnostic phenomenon and that most people who experience PLEs have a primary mood or anxiety disorder (van Os and Reininghaus, 2016). Previous studies that have investigated the impact of PLEs on future psychotic experiences, while also adjusting for comorbid symptoms, have shown mixed results. In a British study of the association between PLEs and poor social functioning, the association disappeared after adjusting for emotional problems, such as depression, and behavioral symptoms, such as conduct disorder (Asher et al., 2013). In other studies, PLEs at childhood predicted PLEs three years later (Giocondo et al., 2021) and higher rates of schizophrenia at adulthood (Fisher et al., 2013) even after accounting for childhood psychopathology.

Sex differences in PLEs have been described in the literature; for example, females report more hallucinations (Johns et al., 2004; Scott et al., 2008) and persecutory ideas (Ziermans, 2013), whereas males report more paranoid thoughts (Johns et al., 2004) and grandiosity (Ziermans, 2013), and have a higher frequency of schizophrenia (Aleman et al., 2003). However, there is conflicting research about whether males or females are more prone to PLEs. Some studies have reported that PLEs are more common in child and adolescent males (Laurens et al., 2007; Poulton et al., 2000), whereas another study found that PLEs are more common in adolescent females (Zammit et al., 2013). Considering the association between PLEs, schizophrenia, and psychosis, it is important to investigate whether the stability of PLEs also differs according to sex. Differences between males and females in PLEs could be important for informing intervention strategies, which may need to be tailored to be effective.

To summarize, PLEs at an early age seem to be a risk factor for future PLEs or even psychotic disorders, which often debut during late adolescence or early adulthood (Solmi et al., 2021). Since early interventions before or at the first onset has the potential to alter the course of the disorders and improve future outcomes (Solmi et al., 2021), it is important to examine PLEs in adolescents and to elucidate the stability of PLEs into adulthood. However, it remains unclear whether PLEs can be regarded as a unique risk factor for future PLEs or as a symptom of general psychopathology. It is also unclear whether there is a sex-specific effect on the association between PLEs during adolescence and adulthood, and whether people with persistent PLEs differ from those with transient symptoms. In this study, we investigated whether i) PLEs are a unique predictor of future PLEs after adjusting for baseline comorbidities, ii) the association between PLEs in adolescence and young adulthood differs between males and females, and iii) specific PLEs and comorbidity at the baseline differ between people with more persistent PLEs and those with remitting PLEs.

2. Methods

2.1. Procedures and participants

In 2012, all adolescents born in 1997 or 1999 and living in the Swedish county of Västmanland were included in a prospective cohort study (the Survey of Adolescent Life in Västmanland, SALVe cohort; Vadlin et al., 2018). The participants and their parents were contacted by regular mail and asked to participate in the study by completing a self-report questionnaire. The questionnaire contained questions about the participants' mental health and sociodemographic factors. The response rate was 40 % and 1834 adolescents participated at the baseline. Six years later, in 2018, the adolescents were contacted by regular mail and again asked to complete the self-report questionnaire. The total study population that completed the questionnaire at both times was 1174. After excluding participants who lacked data for any of the study variables, the final study population included 1146 (62.1 % females) whose mean age was 14.36 years (SD, 1.04) at the baseline and 20.15 years (SD, 1.08) 6 years later in 2018. Most were of Nordic origin (i.e., participants and both parents born in Denmark, Finland, Iceland, Norway, or Sweden = 80.7 %), and had both parents working or studying (87.1 %) and living together (70.3 %). None of the participants had a diagnosis of schizophrenia according to parent-reports, although one parent, one sibling and 9 other relatives had a reported diagnosis of schizophrenia.

Compared with those not included (i.e., non-responders at the follow-up), the responder group had fewer attention-deficit/hyperactivity disorder (ADHD) symptoms ($t = 3.39$; $p = 0.001$), fewer symptoms of conduct disorder ($t = 3.67$; $p < 0.001$), more females ($\chi^2 = 53.36$; $p < 0.001$), and higher percentages of Nordic origin ($\chi^2 = 4.45$; $p = 0.035$) and parents who were employed ($\chi^2 = 8.74$; $p = 0.003$). No difference in frequency or number of reported PLEs were found between the two groups. Ethical approval for the study was obtained from the Ethical Review Board in Uppsala, Sweden, in concordance with the Declaration of Helsinki. Written informed consent to participate in the study was obtained from the adolescents and their parents.

2.2. Measures

2.2.1. PLEs

PLEs were measured by self-rating at both times using a scale that was developed for the early detection of PLEs in child and adolescent community populations (Isaksson et al., 2020; Laurens et al., 2007; Vadlin et al., 2016). The scale has shown good internal consistency for child, caregiver (Laurens et al., 2007), and adolescent reports (Isaksson et al., 2020), and the items load on a single latent psychotic-like construct, discriminable from internalizing and externalizing problems, in the general child population (Laurens et al., 2012). In general, self-reported questionnaires have been shown to be useful to identify adolescents who have experienced PLEs, with auditory and visual hallucinations having the greatest predictive power (Kelleher et al., 2011). The scale comprises nine questions about PLEs: “Some people believe that their thoughts can be read. Have other people ever read your thoughts?”, “Have you ever believed that you were being sent special messages through the television?”, “Have you ever thought that you were being followed or spied upon?”, “Have you ever heard voices that other people could not hear?”, “Have you ever felt as though your body had been changed in some way that you could not understand?”, “Have you ever felt that you were under the control of some special power?”, “Have you ever known what another person was thinking even though

that person wasn't speaking?", "Do you have any special powers that other people don't have?", and "Have you ever seen something or someone that other people could not see?". PLEs were rated on a three-point scale (0 = not true, 1 = sometimes, and 2 = often). The total score ranged from 0 to 18, with higher scores indicating more PLEs.

We used Cronbach's α to calculate the internal consistency, which was 0.79 at the baseline and 0.80 at 6 years later. The adolescents also indicated whether they had experienced PLEs in the past year, PLEs were interfering with daily function, or PLEs were causing any worries, all rated "yes" or "no". We dichotomized the number of PLEs where individuals who scored four points or more (a cut-off previously used for this scale; Laurens et al., 2007; Vadlin et al., 2016), and had PLEs the last year, were categorized as having PLEs, whereas those who had scored less than four points, or not had PLEs the last year, were categorized as not having PLEs at the time point.

2.2.2. Depression

Depressive symptoms at the baseline were measured using the Depression Self-Rating Scale for Adolescents (DSRS-A), which is a self-rating scale used to screen for major depressive disorder based on the Diagnostic and Statistical Manual of Mental Disorders (DSM) IV. The original validation study on DSRS was conducted in 83 adult psychiatric in- and outpatients, and the DSRS had a sensitivity of 86 % and a specificity of 75 % compared with an expert rated diagnosis (Svanborg and Ekselius, 2003). DSRS-A has been validated in a community-based sample of adolescents and child- and adolescent psychiatric outpatient settings in Sweden, reporting a moderate concurrent validity and moderate diagnostic accuracy (Sonnby et al., 2021). The study population answered 15 questions about depressive symptoms that had occurred in the past 2 weeks as either "yes" or "no." Cronbach's α was 0.80. We created a depression index by summing the reported symptoms. Although some items on the DSRS refer to the same symptom, we counted each symptom only once (Isaksson et al., 2020), which produced a depression index range of 0–9, with a higher score indicating more depressive symptoms.

2.2.3. Anxiety

Anxiety symptoms at the baseline were measured using the Spence Children's Anxiety Scale (Spence, 1997). The scale has been shown to have good to excellent internal reliability, and concurrent and discriminant validity, in both population-based (Essau et al., 2011) and clinical populations (Olofsdotter et al., 2016). The participants answered 38 questions on a four-point scale (0 = never, 1 = sometimes, 2 = often, 3 = always). The total score was 0–114, with a higher score indicating more anxiety, including panic/agoraphobia, separation anxiety, specific phobias, social phobia, obsessive compulsiveness, and generalized anxiety. Cronbach's α was 0.91.

2.2.4. ADHD

Symptoms of ADHD at the baseline were measured using the Adult ADHD Self-Report Scale, Adolescent version (ASRS-A-S, Kessler et al., 2005). The ASRS is a self-rating screening scale of 18 questions about the frequency of recent DSM-IV criteria for ADHD with response options ranging from 0 = never to 4 = very often. The sum of all items (0–72) was used, with higher scores indicating a greater likelihood of having ADHD symptoms. The scale has been shown to have high internal consistency and concurrent validity in both general and clinical populations (Kessler et al., 2005; Sonnby et al., 2015). Cronbach's α was 0.90.

2.2.5. Conduct disorder

Symptoms of conduct disorder at the baseline were measured using a self-report questionnaire based on a questionnaire developed by Andershed et al. (2002), which was edited to also include common disruptive behavior (Åslund et al., 2011). Respondents answered 26 questions about the frequency of symptoms of conduct disorder on a five-point scale (0 = never, 1 = once, 2 = 2–4 times, 3 = 5–10 times, and 4 ≥ 10 times). The score had a range of 0–104 where higher scores indicated more conduct problems. Cronbach's α was 0.78.

2.2.6. Socioeconomic status

To estimate socioeconomic status (SES), we used the occupational status of the participants' parents as a proxy. SES was categorized as 1 = both parents were working or studying, and 0 = other (i.e., either or both parents were not working or studying).

2.3. Statistical analysis

All statistics described in this study were performed using IBM Statistical Package for the Social Sciences (SPSS, version 27). The chi-square test was used to compare reported PLEs between males and females. The independent-sample *t*-test was used to calculate the mean differences in concurrent and baseline psychiatric symptoms between participants having PLEs and those not having PLEs in young adulthood. Logistic regression analysis was used to assess whether having PLEs at the baseline (adolescence) predicted having PLEs 6 years later (young adulthood). The logistic regression analysis included two steps. Step 1 was adjusted for sex, origin (Nordic origin coded as 0 and non-Nordic as 1), age, and SES. Step 2 also adjusted for symptoms of depression, anxiety, ADHD, and conduct disorder at the baseline. As sensitivity analyses we re-calculated the full model with having both PLEs 6 years later and reported functional impairment as outcome. We also included impairment and/or worries associated with PLEs at baseline in order to investigate if associated distress increase the risk for PLEs 6 years later (having PLEs without distress were coded as 0, and PLEs + associated impairment or worries as 1). The Nagelkerke R^2 is a pseudo R^2 statistic that estimates the model fit for logistic regression. Lastly, we compared the baseline characteristics between participants who had PLEs at both times with those who had PLEs only at the baseline. Two-tailed tests with p values <0.05 were considered to be significant.

3. Results

3.1. Associations between the study variables

Of the 1146 participants in the study, 15.5 % had PLEs at the baseline (adolescence) and 11.9 % had PLEs 6 years later (early adulthood). More females than males reported PLEs at the baseline (18.1 % vs 11.3 %; $\chi^2 = 9.58$; $p = 0.002$), but no statistically significant sex difference was found in young adulthood (12.6 % vs 10.6 %; $\chi^2 = 1.07$; $p = 0.300$). Of participants reporting PLEs, 14.1 % of those who experienced PLEs as an adolescent and 19.1 % as an adult reported that the PLEs resulted in functional impairment. Of participants reporting PLEs, 46.1 % of those who experienced PLEs as an adolescent and 52.9 % as an adult recorded that they had been worried by the experience.

The most frequently reported PLEs (rated as "sometimes" or "often") during adolescence were being spied upon or stalked (24.5 %), followed by being able to read others' thoughts (24.3 %), and others being able to read their thoughts (17.0 %). In early adulthood, the most frequently reported PLEs were being able to read others' thoughts (23.3 %), being spied upon or stalked (21.0 %), and others being able to read their thoughts (17.2 %). As shown in Table 1, those who reported PLEs in early adulthood scored higher on all psychiatric symptoms during both adolescence and in early adulthood.

3.2. Results of the logistic regression

Table 2 shows the results of the logistic regression analysis that included having PLEs in young adulthood as the outcome. In step 1, having PLEs at the baseline predicted having PLEs 6 years later after adjusting for sex, origin, age, and SES (odds ratio (OR) 5.15, $p < 0.001$). In the full model, after adjusting for psychiatric comorbidity, PLEs at the baseline still predicted PLEs 6 years later (OR 3.83, $p < 0.001$). Anxiety

Table 1
Mean differences identified using an independent-sample *t*-test in preceding and concurrent psychiatric symptoms between participants who reported and did not report PLEs in early adulthood.

	Whole sample	Having PLEs (≥4 points and last year) in adulthood (n = 136)	No PLEs (<4 points or not last year) in adulthood (n = 1010)	t value p value
PLEs reported at B Mean (SD)	2.20 (2.53)	2.96 (3.75)	1.15 (2.20)	$t = 5.50$, $p < 0.001$
PLEs reported at F Mean (SD)	1.64 (2.35)	6.26 (2.76)	0.50 (0.93)	$t = 24.18$, $p < 0.001$
Depressive symptoms[a] B, Mean (SD)	1.82 (2.14)	2.66 (2.34)	1.71 (2.08)	$t = 4.53$, $p < 0.001$
Depressive symptoms[a] F, Mean (SD)	3.06 (2.83)	4.91 (2.77)	2.82 (2.75)	$t = 8.34$, $p < 0.001$
Anxiety[b] B, Mean (SD)	18.68 (12.86)	25.41 (15.50)	17.77 (12.19)	$t = 5.52$, $p < 0.001$
Anxiety[b] F, Mean (SD)	12.79 (9.34)	19.77 (10.41)	11.84 (8.78)	$t = 8.49$, $p < 0.001$
ADHD symptoms[c] B, Mean (SD)	19.15 (10.67)	22.13 (10.46)	18.75 (10.64)	$t = 3.49$, $p = 0.001$
ADHD symptoms[c] F, Mean (SD)	21.91 (11.75)	29.85 (11.74)	20.84 (11.34)	$t = 8.66$, $p < 0.001$
Conduct problems B, Mean (SD)	4.85 (5.52)	5.78 (6.05)	4.73 (5.43)	$t = 2.09$, $p = 0.037$
Conduct problems[d] F, Mean (SD)	0.67 (1.32)	1.02 (1.55)	0.62 (1.28)	$t = 3.34$, $p = 0.001$

PLEs, Psychotic-like experiences. B, Baseline. F, Follow-up 6 years later.
[a] Measured with the Depression Self Rating Scale.
[b] Measured with the Spence Children's Anxiety Scale, at the follow-up with the adult version with 15 items.
[c] Measured with the Adult ADHD Self-Report Scale.
[d] Measured with the adult version with 15 items.

also predicted PLEs in early adulthood (OR 1.02, $p = 0.010$). The full model explained 13 % of the variance in PLEs in early adulthood. No interaction effect of PLEs and sex on future PLEs was found (not shown in the model). When including functional impairment as outcome, PLEs at baseline predicted PLEs with functional impairment 6 years later in the full model (OR 4.00, CI 1.62, 9.93; $p = 0.03$), not shown in Table. Having associated impairment and/or worries at baseline did not increase the risk for PLEs 6 years later as compared to only having PLEs (OR 1.51, CI 0.80, 2.85; $p = 0.20$), not shown in Table.

3.3. Comparison between participants with persistent and transitory PLEs

Most participants (77.5 %) did not report having had PLEs at any time (<4 points or no PLEs in the past year), 10.8 % reported having had PLEs in adolescence only, and 4.9 % reported having had PLEs at both times. Comparison of participants who reported PLEs at both times with those who reported PLEs at the baseline only showed that those with persisting PLEs reported a higher frequency of having seen something or someone that other people could not see and heard voices that other people could not hear or see at the baseline (Table 3). These groups did not differ in other aspects of PLEs, such as PLEs interfering with daily function or PLEs causing any worries. Participants with persistent PLEs also had higher ratings of anxiety at the baseline.

Table 2
Results of binary logistic regression analysis to identify predictors of PLEs in early adulthood.

	Step 1		Step 2	
	OR (95 % CI); SOR[a] (95 % CI)	p value	OR (95 % CI); SOR[a] (95 % CI)	p value
PLEs at baseline	5.15 (3.46–7.68); 1.81 (1.57–2.09)	<0.001	3.83 (2.46–5.97); 1.63 (1.39–1.91)	<0.001
Sex	1.07 (0.72–1.59); 1.03 (0.85–1.25)	0.750	0.91 (0.60–1.39); 0.96 (0.78–1.18)	0.673
Origin	1.52 (0.98–2.35); 1.18 (0.99–1.40)	0.064	1.52 (0.97–2.37); 1.18 (0.99–1.41)	0.065
Age	0.95 (0.79–1.14); 0.95 (0.79–1.14)	0.576	0.93 (0.77–1.13); 0.93 (0.76–1.13)	0.458
SES	0.61 (0.37–1.00); 0.85 (0.72–1.00)	0.049	0.63 (0.38–1.04); 0.86 (0.72–1.01)	0.068
Depression			1.01 (0.90–1.13); 1.01 (0.79–1.30)	0.920
Anxiety			1.02 (1.01–1.04); 1.36 (1.08–1.73)	0.010
ADHD			1.00 (0.97–1.02); 0.95 (0.74–1.22)	0.668
Conduct disorder			1.01 (0.97–1.05); 1.05 (0.86–1.28)	0.611

OR, Odds ratio; CI, Confidence interval; PLEs, Psychotic-like experiences (≥4 points and last year); SES, Socioeconomic status; SOR, Standardized odds ratio. Step 1 adjusted for PLEs at the baseline, sex, origin, age, SES. Step 2 additionally adjusted for depression, anxiety, ADHD, and conduct disorder at the baseline.
[a] Standardized odds ratios (the independent variables are converted into *Z*-scores).

4. Discussion

In this prospective cohort study, we found that self-reported PLEs during early adolescence predicted having PLEs 6 years later in young adulthood. The associations remained after adjusting for concordant psychiatric comorbidity at the baseline; having PLEs in adolescence was associated with an almost four times greater odds of having PLEs during adulthood. The association between baseline and future PLEs did not differ between males and females, although females were more likely to report PLEs during adolescence. Participants with persistent PLEs reported a higher frequency of visual and auditory hallucination and greater anxiety in adolescence.

One-sixth of the participants reported PLEs as an adolescent and one-tenth as a young adult. The most frequent PLEs were being able to read others' thoughts, being spied upon or stalked, and that others were able to read their thoughts. A similar prevalence (14.7 %) was reported in an interview-based study of PLEs in 11-year-olds (Poulton et al., 2000). Other studies have reported lower prevalence rates. In a systematic review and meta-analysis of 47 studies that investigated the prevalence of PLEs, van Os et al. (2009) reported a median prevalence rate of 5 % in the general population. Similarly, another review by Kelleher et al. (2012a) that focused on PLEs in adolescents aged 13–18 years reported a prevalence rate of 7.5 %. Comparing PLEs between studies is difficult because of the diverse definitions and tools to identify PLEs (Lee et al., 2016). The reviews by van Os et al. (2009) and Kelleher et al. (2012a) reported on studies that used both interviews and questionnaires. Van Os et al. (2009) discussed that interviews conducted by clinicians were superior to self-rating and lay interviewers, which may have increased the risk of false positives in some studies. At the same time, it has been argued that children are more at ease reporting such experiences using questionnaires rather than reporting to a caregiver or a clinician during an interview (Laurens et al., 2007). In the current study, the incidence of PLEs decreased from adolescence to early adulthood, which is to be expected based on previous research that found that the rate of hallucinations decreased from 6 % in early adolescence to 3 % in young adulthood (Dhossche et al., 2002).

Participants with PLEs in early adulthood had higher ratings on all

Table 3
Differences identified using the chi-square test and *t*-test in baseline ratings between participants with PLEs at both times ($n = 56$) and those who had PLEs only at the baseline ($n = 124$).

	Having PLEs (≥4 points and last year) in adolescence and adulthood			Having PLEs (≥4 points and last year) only in adolescence			χ^2 or *t* value
	Not true	Sometimes	Often	Not true	Sometimes	Often	
Having thoughts read	25.5 %	65.5 %	9.1 %	25.0 %	58.9 %	16.1 %	$\chi^2 = 1.63$
Special messages	49.1 %	43.6 %	7.3 %	49.2 %	45.1 %	5.7 %	$\chi^2 = 0.16$
Spied upon or stalked	9.1 %	69.1 %	21.8 %	15.3 %	60.5 %	24.2 %	$\chi^2 = 1.64$
Hearing voices	25.0 %	55.4 %	19.6 %	44.4 %	45.2 %	10.5 %	$\chi^2 = 7.03$*
Controlled by an outside force	66.1 %	32.1 %	1.8 %	79.0 %	20.2 %	0.8 %	$\chi^2 = 3.52$
Reading thoughts	8.9 %	66.1 %	25.0 %	17.7 %	63.7 %	18.5 %	$\chi^2 = 2.81$
Unexplainable body changes	66.1 %	33.9 %	0.0 %	61.0 %	35.8 %	3.3 %	$\chi^2 = 2.02$
Special powers	46.4 %	42.9 %	10.7 %	53.2 %	37.1 %	9.7 %	$\chi^2 = 0.72$
Seeing things others cannot	14.5 %	69.1 %	16.4 %	45.9 %	42.6 %	11.5 %	$\chi^2 = 16.23$***
Being worried	53.6 %			41.9 %			$\chi^2 = 2.11$
Caused impairment	14.3 %			13.8 %			$\chi^2 = 0.01$
Sex (female)	70.2 %			76.8 %			$\chi^2 = 0.84$
Depressive symptoms	3.93 (2.35)			3.26 (2.60)			$t = 1.65$
Anxiety	34.29 (16.21)			28.33 (14.52)			$t = 2.46$*
ADHD symptoms	25.61 (10.11)			25.76 (10.93)			$t = 0.09$
Conduct problems	6.77 (7.26)			6.89 (7.20)			$t = 0.10$

* $p < 0.01$.
*** $p < 0.001$.

previously and concurrently reported symptom categories, including PLEs in adolescence. In our logistic regression analysis, the OR decreased from 5.15 when not adjusted for psychiatric comorbidity to 3.83, and still significant, when adjusted for this comorbidity. Our findings suggest that the occurrence of PLEs in early adolescence is a unique risk factor for predicting future PLEs in early adulthood. It is not clear whether this result can be compared with those of previous research because few studies have used future PLEs as an outcome. Corroborating our finding, Giocondo and colleagues found that higher levels of PLEs among 6–12-year-olds were associated with increased PLEs 3 years later even after adjusting for baseline common mental disorders (Giocondo et al., 2021). In a birth cohort followed over a longer time period, having PLEs at age 11 years increased the risk of having a future diagnosis of schizophrenia assessed at age 38 years, and the association remained significant after adjusting for confounders such as psychiatric comorbidity (Fisher et al., 2013). Similarly, a study of people who exhibited PLEs at age 12 years and psychotic disorders at age 18 years found that having had PLEs increased the risk of future psychotic disorders (Zammit et al., 2013). However, the study by Zammit and colleagues did not take psychiatric comorbidity into account.

Previous research has found that including measures of distress related to PLEs improved prediction of clinical high-risk status (Kline et al., 2014). However, within our longitudinal design, PLEs with distress did not increase the risk for future PLEs, and those with persistent PLEs did not have higher baseline ratings of impairment or worries associated with PLEs. Compared to Kline and colleagues, we had a rather crude measure of distress (i.e., yes or no) and a more comprehensive assessment could have yielded other findings. In the fully adjusted model, we found that higher levels of anxiety during adolescence predicted PLEs in adulthood. This association between internalizing symptoms, such as anxiety, and PLEs is consistent with previous research showing that children with persisting PLEs are almost twice as likely to experience emotional symptoms or difficulties with peer relationships (Downs et al., 2013). PLEs in adolescents have been shown to predict internalizing symptoms 3 years later after adjusting for comorbidity in the analysis (Isaksson et al., 2020).

Participants with persistent PLEs reported more symptoms of hallucination during adolescence, more specifically seeing things that others cannot see and hearing voices that other people could not hear. Our questionnaire for measuring PLEs restrict us from exploring in more detail how these hallucinations differs between those with persistent or transient PLEs. Previous research on auditory verbal hallucinations have reported that hallucinations are associated with a more clinical phenotype if having a negative emotional valance, being associated with a lower degree of control (Daalman et al., 2011; Johns et al., 2014), a later onset (Daalman et al., 2011), and where a family history of psychosis and childhood adversity are present (Johns et al., 2014). We also found that symptoms of anxiety were higher in those who reported PLEs as both adolescents and adults. Despite these previous findings, the authors of a scoping review concluded that there is little useful information for identifying which children/adolescents with PLEs at an initial assessment are likely to have persistent PLEs at subsequent assessments and that none of the findings included in that review was identified by more than one study (Kalman et al., 2019).

In our study, PLEs were reported more frequently in females during adolescence but not in early adulthood. As mentioned earlier, in our study the number of participants reporting PLEs decreased between the two time points. The decrease was attributed almost exclusively to a decrease among females: the frequency decreased from 18.1 % in adolescence to 12.6 % in adulthood in females and from 11.3 % to 10.6 % in males. Previous longitudinal studies have not reported pronounced decreases in females only (De Loore et al., 2011; Dominguez et al., 2011; Kirli et al., 2019). However, considering that psychosis can be regarded as the extreme end of the spectrum (van Os et al., 2009) and that psychosis is more common in males, who also develop schizophrenia at an earlier age (Aleman et al., 2003), it can be hypothesized that symptoms are more stable and long-lasting for males. Accordingly, we also found a trend suggesting that more males than females had persistent PLEs. Further research on sex differences in PLEs is needed.

Our study has several strengths, such as its prospective cohort design with a large study population, adjustments for psychiatric comorbidity, and use of future PLEs as an outcome, which was uncommon in previous studies. However, our study also has several limitations. First, the data on PLEs came from self-ratings, and we cannot exclude other possible explanations of the symptoms such as sleeping problems or having a fever (Zammit et al., 2013). The PLE scale has not been thoroughly validated in adolescent populations, and diagnostic interviews would be preferable as a complement to the self-rating scales to produce more accurate results. Second, we did not account for all factors that are associated with increased risk for PLEs, such as posttraumatic stress disorder (Calkins et al., 2014), substance use (Cederlöf et al., 2017), recent stressful life events, autism spectrum disorder (Jutla et al., 2021), lower working memory capacity (Ziermans, 2013), and lower

intellectual ability (Johns et al., 2004). Family history of a mental disorder has been shown to be of importance for future PLEs (Kirli et al., 2019), which may also affect the results. Third, although the proportion of nonresponders was similar to that in similar questionnaire-based cohort studies (Tambs et al., 2009), our study had a considerable attrition rate. Non-responders had more symptoms of ADHD and conduct disorder, were more males and of non-Nordic origin, with unemployed parents. This may have resulted in selection bias. However, previous research has reported that loss due to nonresponse at the follow-up rarely affects estimates of association (Saiepour et al., 2019; Wolke et al., 2009). Furthermore, as shown in Supplementary Table 1, the result were basically the same when we ran the analyses on imputed data, with PLEs at baseline predicting PLEs 6 years later (OR 3.89, CI 2.45, 6.15; $p > 0.001$).

5. Conclusions

Our findings suggest that the early experience of PLEs is an important and independent predictor of future PLEs, which contribute to psychiatric comorbidity. Even though these are common at the trait level, PLEs during adolescence should be taken seriously and carefully monitored because they can be a precursor to psychotic illness. Because PLEs are associated with a wide array of psychiatric disorders, the occurrence of PLEs is a potential antecedent and pluripotent marker for psychiatric disease. Our findings highlight the importance of measuring and possibly screening for PLEs in young adolescents to identify individuals with a high risk of future psychopathology and to enable early interventions. Hallucinations were found to be associated with more persistent PLEs throughout maturation to adulthood. Future studies should focus on PLEs in clinical samples and should also consider their contribution to disability.

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CRediT authorship contribution statement

Author JI conducted the statistical analyzes and drafted the manuscript together with MA, author SV and SO designed the study and were responsible for the data collection. All authors read and approved the final manuscript.

Data availability statement

Reasonable requests for patient-level data should be made to the corresponding author and will be considered after discussion with the ethical board. Relevant data is included in the manuscript.

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Declaration of competing interest

The authors have declared that there are no conflicts of interest in relation to this study.

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