Schizophrenia Research 127 (2011) 252–256

Contents lists available at ScienceDirect

Schizophrenia Research

journal homepage: www.elsevier.com/locate/schres

# Persistence and outcome of auditory hallucinations in adolescence: A longitudinal general population study of 1800 individuals

Ellen De Loore [a,b,1], Nicole Gunther [a,c,1], Marjan Drukker [a,d], Frans Feron [d,e], Bernard Sabbe [b], Dirk Deboutte [b], Jim van Os [a,f], Inez Myin-Germeys [a,*]

[a] Department of Psychiatry and Neuropsychology, South Limburg Mental Health Research and Teaching Network, EURON, Maastricht University, Maastricht, The Netherlands
[b] Collaborative Antwerp Psychiatric Research Institute (CAPRI), University Antwerp, Antwerp, Belgium
[c] School of Psychology, Open University, Heerlen, The Netherlands
[d] Youth Health Care Division, Public Health Service South Limburg, Maastricht, The Netherlands
[e] Department of Social Medicine, Faculty of Health, Medicine and Life Sciences, Maastricht University, Maastricht, The Netherlands
[f] King's College London, King's Health Partners, Department of Psychosis Studies, Institute of Psychiatry, London, UK

ARTICLE INFO

*Article history:*
Received 22 September 2010
Received in revised form 14 January 2011
Accepted 16 January 2011
Available online 18 February 2011

*Keywords:*
Hallucinations
Adolescence
Psychotic disorder
General population

ABSTRACT

*Background:* Auditory hallucinations are common in adolescents. However, it has been suggested that not the presence of low-grade psychotic experiences per se, but rather the level of persistence and associated clinical complications over time may lead to psychotic illness. The current paper investigated, in a large representative sample of adolescents, to what degree hallucinations persist, and whether persistence of hallucinations increases the risk of developing secondary delusional ideation and affective dysregulation.
*Methods:* Data were derived from a general health screening of all 1912 adolescents living in the Maastricht area. Baseline assessment was in the second grade of secondary school (T0) and follow-up occurred 2 years later (T1). Questions included the psychosis screening questions (Poulton et al., 2000), the SDQ assessing general psychopathology and a question assessing depression.
*Results:* Five percent of adolescents reported hallucinations at T0 and 27% of these hallucinations were still present 2 years later. Hallucinations at T0 were associated with increased levels of depressed mood and general psychopathology at T1, and the degree of persistence of hallucinations was associated with a progressively greater risk for T1 delusional ideation as well as increased levels of follow-up depressed mood and general psychopathology.
*Conclusion:* Although hallucinations in adolescents are a common and mainly transitory phenomenon, the persistence rate over time is far from negligible, and associated with clinical deterioration.


## 1. Introduction

Population-based epidemiological studies have shown that auditory hallucinations are common, particularly in younger age groups including children and adolescents, with prevalence rates ranging from 5.7 to 21.0% ( Bartels-Velthuis et al., 2010; Dhossche et al., 2002; Escher et al., 2002b; Mcgee et al., 2000; Van Os et al., 2009; Yoshizumi et al., 2004). For the majority of children and adolescents, these experiences are well below the threshold of clinical disorder (Schreier, 1999; Tien, 1991), and tend to have a benign course (Yoshizumi et al., 2004). A 3-year follow-up study showed that auditory hallucinations in children were transitory in 60% (Escher et al., 2002b). On the other hand, studies have demonstrated that hallucinatory experiences in childhood may increase the risk for later mental health problems (Dhossche et al., 2002; Mcgee et al., 2000), including psychotic disorders in adulthood (Ohayon, 2000; Poulton et al., 2000).

Although there is a rapidly growing number of cross-sectional surveys on psychotic experiences in non-ill individuals, a dearth in longitudinal work in representative general population samples remains. From a perspective of prediction and prevention, it is crucially important to understand the mechanism underlying the transition from subclinical hallucinations to the development of a full-blown psychotic disorder in representative samples. Previous longitudinal work in representative samples has shown that not the presence of low-grade psychotic experiences in the general population per se, but rather the persistence and clinical deterioration of these experiences over time may lead to a clinical state of psychosis (Cougnard et al., 2007; Dominguez et al., 2011; Mackie et al., 2010). These earlier studies, however, did not differentiate between hallucinations and other low-grade psychotic experiences, in particular delusional ideation which in the general population is much more prevalent than hallucinatory experiences and may represent a weaker predictor of clinical transition

* Corresponding author. Department of Psychiatry and Neuropsychology, Maastricht University, PO BOX 616 (VIJV), 6200 MD Maastricht, The Netherlands. Tel.: +31 43 3688683; fax: +31 43 3688689.
*E-mail address:* i.germeys@maastrichtuniversity.nl (I. Myin-Germeys).
[1] Joint first authorship.

0920-9964/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.schres.2011.01.015

(Van Os et al., 2009). Several psychological accounts of psychosis indicate that perceptual aberrations, such as hallucinations, may be at the core of psychosis. Hallucinations may predispose to psychosis by secondary formation of delusional ideation in an attempt to explain perplexing perceptual experiences ( Bentall et al., 2001; Escher et al., 2002a; Garety et al., 2001; Maher, 1974), which subsequently may provoke affective dysregulation and emotional distress (Morrison, 2001; Smeets et al., in press; Van Rossum et al., in press)

Bringing together these strands of evidence gives rise to the hypothesis that not the mere occurrence of a hallucination, but rather the persistence of hallucinations over time may predispose to the secondary formation of delusions and affective dysregulation. The current paper aims to investigate, in a large sample of representative adolescents in the general population, to what degree hallucinations persist, and whether persistence of hallucinations increases the risk of developing secondary delusional ideation and affective dysregulation.

## 2. Methods

### 2.1. Participants

All children in the Netherlands aged 4–16 years are examined regularly by the Youth Health Care Divisions (YHCD) of (Regional) Public Health Services. To this end, parents of the younger children as well as adolescents aged 13 years and older are asked to fill in a questionnaire together with the medical examination. Health information aimed at detecting and remediating physical and mental health problems as well as background characteristics (e.g. type of secondary education) were derived from these questionnaires, which were compiled in the context of an academic partnership between YHCD and Maastricht University in Maastricht, The Netherlands (Drukker et al., 2009; Gunther et al., 2003). The present study used two waves of these Regional Profiles of Youth health (RPY), pertaining to 1912 adolescents living in Maastricht and surrounding areas (total population of 201,000) who were attending the second grade of secondary school at T0 (age 13/14 years) and who were seen again approximately 2 years later at T1 whilst attending the fourth grade (age 15/16 years).

### 2.2. Assessments

The following self-reported variables were derived from the RPY data.

Both auditory hallucinations at T0 and T1 were assessed with the question rated, by the individual, as yes or no: "Have you ever heard voices other people cannot hear?". Auditory hallucinations at T0 and T1 were combined into one persistence variable (0 = no hallucinations; 1 = hallucinations at T0 but not at T1, 2 = hallucinations both at T0 and T1).

Delusional ideation at T0 and at T1 was assessed with 3 questions rated as yes or no: (1) "Some people believe in mind reading or being psychic. Have other people ever read your mind?", (2) "Have you ever had messages sent just to you through television or radio?", (3) "Have you ever thought that people are following you or spying on you?". These questions were derived from the Diagnostic Interview Schedule for Children (DISC-C) (Costello et al., 1982) for DSM-III (APA, 1980), and were used previously by Poulton et al. (2000) and formally validated by various groups (Kelleher et al., 2009; Polanczyk et al., 2010). Ratings of delusional thought questions were combined into a single measure with a value of 1 indicating presence of at least one symptom and a value of 0 indicating the absence of delusional ideation. The question about reading thoughts was not included in the psychosis-measure in the current paper, as 30% of all subjects at T0 and 33% at T1 answered yes to this question, which is much higher than would be expected on the basis of other studies (Van Os et al., 2000, 2009). This question therefore was considered as lacking in discriminative power in this age group and was excluded from the analysis.

General psychopathology was measured at T0 and T1 using the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997). The SDQ is a brief questionnaire, assessing symptoms of psychopathology in children and adolescents. A self-report version that can be completed independently by 11 to 16 years old was used for the present analyses (Becker et al., 2004). The SDQ consists of 25 items, generating sum scores for five subscales: emotional symptoms (e.g. "I have many fears; I am easily scared"), conduct problems (e.g. "I get very angry and often lose my temper"), hyperactivity–inattention (e.g. "I am easily distracted; I find it difficult to concentrate"), peer problems ("I am usually on my own; I generally play on my own or keep to my self"), and prosocial behaviour (e.g. "I often volunteer to help others"). Each item can be scored on a 3-point scale with 0 = 'not true', 1 = 'somewhat true', and 2 = 'certainly true'. Higher scores on the prosocial behaviour subscale reflect strengths, whereas higher scores on the other four subscales reflect difficulties. The internal consistency of the SDQ total score ($\alpha = 0.63$) was acceptable. For the present study, a standardized total psychopathology symptom score (range 0–40), based on all scales with the exception of the prosocial scale was used.

Depressed mood at T0 and T1 was assessed with the following statement:" I am concerned about having low mood and I would like to talk to the nurse about it." Depressed mood was rated as 'yes' (value 1) or 'no' (value 0).

A priori confounders included in the statistical models were age, sex, educational level at T1 (as an indicator of socio-economic status) and duration of follow-up (time between T0 and T1 in months) [range 3–44 months]. Educational level was divided in five categories: 1: pre-university education; 2: higher general secondary education; 3: highest level of technical and vocational training for 12–16 years old; 4: medium level of technical and vocational training for 12–16 years old; and 5: lowest level of technical and vocational training for 12–16 years old.

### 2.3. Statistical analyses

All analyses were carried out in STATA, version 11.1 (Statacorp, 2009).

#### 2.3.1. Persistence of auditory hallucinations

In order to evaluate whether the presence of auditory hallucinations at T0 increased the risk of auditory hallucinations at T1, a logistic regression analysis was carried out with "auditory hallucinations at T1" as dependent variable and "auditory hallucinations at T0" as independent variable, the resulting odds ratio reflecting degree of persistence (Cougnard et al., 2007).

#### 2.3.2. Consequences of persistent hallucinations

In order to investigate whether persistent hallucinations predicted poorer outcome, associations between persistent auditory hallucinations on the one hand and, on the other (i) development of delusional ideation, (ii) levels of psychopathology as measured by the SDQ, and iii) depressed mood, were assessed.

Logistic regression analyses were conducted with "delusional ideation at T1" or "depressed mood at T1" as dependent variable and "persistence of auditory hallucinations" as independent variable, controlling for any delusional ideation at T0 or depressed mood at T0 respectively (Escher et al., 2002b). Similarly, linear regression analyses were used to assess associations between psychopathology at T1 and persistence of auditory hallucinations, controlling for psychopathology at T0. All analyses were adjusted for age, gender, socio-economic status and duration of follow-up. Finally, all analyses were adjusted for all the baseline psychopathology measures (delusional ideation, general psychopathology, and depressed mood). Results of logistic regression analyses were expressed as odds ratios (OR), whereas linear regression analysis yielded regression coefficients (*B*-values). Effect sizes were evaluated by the (chi-square) Wald test, a test used to test the

significance of particular explanatory variables in a statistical model (Clayton and Hills, 1993).

## 3. Results

### 3.1. Descriptive statistics

The sample at baseline consisted of 1912 subjects. Three subjects were excluded because they were assessed only once, 31 subjects had missing data on the hallucination items, and another 98 subjects had missing values on one of the demographic variables, leaving a risk set of 1780 participants. See Table 1 for the descriptives of the sample.

### 3.2. Do auditory hallucinations persist?

Of the 93 adolescents with hallucinations at T0, 27% reported persistent hallucinations at T1 ($n=25$). The risk of experiencing hallucinations at T1 was significantly greater in this group, compared to the adolescents who did not report hallucinations at T0 ($n=49$ at T1 of $n=1638$ at T0, 3%; adjusted OR = 11.0, $p<0.001$, 95%CI 6.4–19.1).

### 3.3. What are the consequences of persistent auditory hallucinations?

#### 3.3.1. Delusional ideation at T1

Sixty-one adolescents were excluded for this analysis (12 had missing values on delusions and 49 reported incident hallucinations at T1) resulting in a risk set of 1719 participants. Adolescents with hallucinations at T0 only, as well as adolescents with persistent hallucinations, were significantly more likely to report delusional ideation at T1 compared to adolescents with no hallucinations (Table 2). These effect sizes remained significant after controlling for confounders (Table 2). After controlling for delusional ideation at T0 only persistent hallucinations remained significantly associated with T1 delusional ideation, and the difference in effect size between adolescents with persistent and non-persistent hallucinations, after adjustment for confounders and delusional ideation at T0, was statistically significant (Table 2). Additionally controlling for T0 depressed mood and general psychopathology did no substantially change the results (Table 2).

#### 3.3.2. General psychopathology at T1

For these analyses, 6 adolescents had no data on general psychopathology at T0 or T1 and 49 had incident hallucinations at T1, leaving a risk set of 1725. Adolescents with hallucinations at T0 only as well as adolescents with persistent hallucinations were reporting significantly more general psychopathology at T1 compared to adolescents with no hallucinations (Table 1). These effects sizes remained statistically significant after controlling for confounders, for general psychopathology at T0, as well as for T0 delusional ideation and depressed mood (Table 2). A linear dose–response association was found between level of persistence of hallucinations and general psychopathology ($B=1.58$, $p<0.000$, 95%CI: 0.90–2.25). There was no significant difference in effect size between adolescents with and without persistent hallucinations (Table 2).

#### 3.3.3. Depressed mood at T1

The risk set for these analyses consisted of 1731 adolescents (49 were excluded due to incident hallucinations at T1, there were no missing data on depressed mood). Adolescents with non-persistent as well as persistent auditory hallucinations were significantly more likely to report depressed mood at T1. These effect sizes remained significant after controlling for confounders as well as for T0 depressed mood, T0 delusional ideation and T0 general psychopathology (Table 2). Similar to the findings for general psychopathology, a linear dose–response association was found between level of persistence of auditory hallucinations and depressed mood (OR = 4.13, $p<0.000$, 95% CI 2.40–7.12). The difference in effect size between adolescents with persistent and non-persistent hallucinations in the model controlling for confounders and T0 depressed mood was not significant (Table 2).

## 4. Discussion

The findings suggest that auditory hallucinations in young adolescents are a common (about 5%), but mainly transitory phenomenon, persistence occurring in approximately a third of those with auditory hallucinations. Importantly, hallucinations at T0 were associated with increased levels of depressed mood and general psychopathology at follow-up, and the degree of persistence of hallucinations was associated with a linear increase in risk for follow-up delusional ideation as well as increased levels of follow-up depressed mood and general psychopathology, clearly indicative of a poorer outcome.

### 4.1. Persistence of auditory hallucinations

Since data were retrieved from a standard health screening in all school children in the Maastricht area, the sample is uniquely representative, including children of all socio-demographic backgrounds and educational levels, without underlying selections. Prevalence rates are conform previous reports in similar samples (Van Os et al., 2009). A second strength of the study is the longitudinal approach, allowing the study of persistence rates as well as of the temporal dynamics of hallucinations and their consequences. The persistence rate of auditory hallucinations in this study (27%) was similar to that of a follow-up study of prepubertal children, reporting a 1-year persistence rate of 30% (Askenazy et al., 2007). In a follow-up study of auditory hallucinations in adolescents, Escher found a 3-year persistence rate of 40% (Escher et al., 2002b). Given the fact that expression of psychotic symptoms peaks in adolescence and early adulthood and decreases in older age in clinical as well as in non-clinical populations (Rossler et al., 2007; Verdoux et al., 1998), lower rates may be expected in older samples.

### 4.2. Consequences of persistence of auditory hallucinations

The occurrence of hallucinations at T0 was associated with increased levels of general psychopathology and depressive problems, and persistence of auditory hallucinations was associated with a linear increase in poor outcome expressed as increased risk to develop delusional ideation as well as increased levels of depression and general psychopathology. These findings are in accordance with other studies (Escher et al., 2004; Hanssen et al., 2005; Mackie et al., 2010) suggesting

**Table 1**
Demographic characteristics and scores on the dependent and independent variables.

| | | |
|---|---|---|
| Gender (M/F) | | 810/970 |
| Duration of follow-up (in months) | | 19.4 (6.8; 3–44) |
| Education | | |
| Pre-university secondary education | | 352 (20%) |
| Higher general education | | 250 (14%) |
| Lower professional education: highest | | 573 (32%) |
| Lower professional education: medium | | 393 (22%) |
| Lower professional education: lowest | | 212 (12%) |
| | T0<br>M (SD) [range] or *n* (%) | T1<br>M (SD) [range] or *n* (%) |
| Age in years | 13.5 (0.6) [11–16] | 15.1 (0.8) [13–18] |
| Auditory hallucinations present | 93 (5%) | 74 (4%) |
| General psychopathology score | 11.5 (4.4) [0–27.5] | 10.5 (4.7) [0–27] |
| Depressed mood present | 25 (1%) | 28 (2%) |
| Delusional ideation present | 260 (15%) | 250 (14%) |

**Table 2**
Effect sizes of persistent hallucinations in the models predicting T1 delusional ideation, general psychopathology, and depressed mood.

| | Persistence of hallucinations[1] | | | Effect size of 1 versus 0 | Effect size of 2 versus 0 | Effect size of 1 versus 2 |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | OR or *B*, 95%CI | OR or *B*, 95%CI | $\chi^2(1)$ or *F* (1, 1771) |
| T1 Delusional ideation | 19/1627 (11.7%) | 22/67 (32.8%) | 14/25 (56.0%) | OR = 3.68 (2.16–6.26)*** | OR = 9.57 (4.28–21.4)*** | 3.98 * |
| + counfounders[2] | | | | OR = 3.37 (1.96–5.78)*** | OR = 8.03 (3.54–18.20)*** | 3.91 (*) |
| + confounders and T0 delusions | | | | OR = 1.72 (0.96–3.09) | OR = 6.36 (2.67–15.18)*** | 6.31 ** |
| + confounders and T0 (delusions, GP[3], depression) | | | | OR = 1.68 (0.94–3.02) | OR = 5.58 (2.33–13.38)*** | 5.27 * |
| T1 General Psychopathology | M = 10.30 (SD = 4.59) | M = 12.97 (SD = 4.93) | M = 14.45 (SD = 5.27) | $\beta$ = 2.67 (1.55–3.79)*** | $\beta$ = 4.15 (2.33–5.97)*** | 1.87 |
| + counfounders[2] | | | | $\beta$ = 2.36 (1.29–3.43)*** | $\beta$ = 3.34 (1.59–5.09)*** | 0.91 |
| + confounders and T0 GP | | | | $\beta$ = 1.99 (0.94–3.04)*** | $\beta$ = 2.62 (0.90–4.33)** | 0.39 |
| + confounders and T0 (delusions, GP, depression) | | | | $\beta$ = 1.17(0.10–2.25)* | $\beta$ = 2.02 (0.33–3.72)* | 0.73 |
| T1 Depressed mood | 16/1638 (1.0%) | 4/68 (5.9%) | 5/25 (20.0%) | OR = 6.34 (2.06–19.49)** | OR = 25.34 (8.46–75.89)*** | 4.66 * |
| + counfounders[2] | | | | OR = 5.33 (1.69–16.83)** | OR = 16.94 (5.34–53.78)*** | 3.28 (*) |
| + confounders and T0 depression | | | | OR = 4.96 (1.55–15.90)** | OR = 16.16 (5.13–50.86)*** | 3.49 (*) |
| + confounders and T0 (depression, GP, delusions) | | | | OR = 3.61 (1.05–12.46) * | OR = 12.06 (3.63–40.03)*** | 2.48 |

[1]Persistence: 0 = no hallucinations at T0 or T1 (baseline), 1 = hallucinations at T0 but not at T1 (non-persistent hallucinations), 2 = hallucinations at T0 and T1 (persistent hallucinations).
M = mean, SD = standard deviation.
OR = odds ratio, *B* = regression coefficient.
[2]Confounders: age at T0, gender, follow-up period in months and educational level.
[3]General psychopathology.
(*)$p<0.08$, *$p<0.05$, **$p<0.01$, ***$p<0.00$.

that the persistence of psychotic features, such as auditory hallucinations, is associated with a higher likelihood of negative outcomes.

Adverse outcome of persistent hallucinations can be expressed as an increased risk to develop delusional ideation, as it has been emphasized that delusional ideation in response to auditory hallucinations may lead to the maintenance of these psychotic symptoms and the subsequent development of clinical psychotic disorder (Krabbendam et al., 2004; Maher, 1974; Maher, 2006; Morrison, 2001). Delusional ideation may secondarily arise as a result of biased conscious appraisals that abnormal perceptual experiences are externally caused (Garety et al., 2001). Thus, persistence of auditory hallucinations may impact on risk of delusional ideation (Escher et al., 2002a) and emotional disturbance (Escher et al., 2003), that in turn may increase the risk to develop clinical psychosis, requiring need for care (Krabbendam et al., 2004, Preti et al., 2007, Krabbendam et al., 2004, Smeets et al., in press).

Hallucinations may also be more indirectly associated with later delusional ideation and emotional disturbance. For example, the experience of persistent hallucinations may be distressing, resulting in increased risk of cannabis or amphetamine use, which is associated with an enhanced risk of developing psychosis (Minozzi et al., 2010). This may be particularly relevant for young adolescents, since use at an early age has been shown to be especially detrimental (Barkus and Murray, 2010). Hallucinations may also be an earlier indicator compared to delusions of an underlying pathogenic process.

The results of the current study are in agreement with other reported findings (Cougnard et al., 2007; Dominguez et al., 2011; Smeets et al., in press, Van Rossum et al., in press), investigating the mechanism and the impact of persistence of subclinical psychotic experiences in the general population. A number of studies have reported that the normal developmental expression of subclinical psychotic experiences, reflecting behavioural expression of liability for psychotic disorder, is mostly transitory, but may become abnormally persistent when combined with additional environmental risks (Cougnard et al., 2007), negative symptoms (Dominguez et al., 2010), affective dysregulation (Hanssen et al., 2005; Van Rossum et al., in press), or dysfunctional coping (Bak et al., 2003). In addition, Dominguez et al. (2011) reported that the longer subclinical psychotic experiences persist over time, the more likely these experiences result in impairment and clinical psychosis.

The results of this study thus demonstrate that refining analyses to the level of individual symptoms using an epidemiological design may be a powerful tool to disentangle the underlying developmental and psychopathological trajectory resulting in clinical psychosis.

### 4.3. Limitations

The present results should be viewed in the light of several methodological issues.

First, data were derived from standard health screenings including numerous questions regarding a wide range of physical and mental health problems. Consequently, the assessment of certain items was limited in scope and precision. For example, the assessment of hallucinatory experiences was lacking detail with regard to duration and frequency, possible etiological factors and degree of reality attached to these experiences. Our questionnaire method may have failed to differentiate true hallucinations from dreams, fantasy, flashbacks, hypnagogic/hypnopompic hallucinations, illusions or imagery.

Secondly, at the time they were filling in the questionnaire, subjects were aware of the fact that possible problems would be discussed with a nurse during the health screening. It can be argued that some subjects may have underreported auditory hallucinations, delusional ideation and psychological problems. As stated before, this seems unlikely for the psychotic experiences since the rates found in the current study are in accordance with earlier work (Dhossche et al., 2002; Escher et al., 2002a; Ohayon, 2000; Poulton et al., 2000; Tien, 1991; Van Os et al., 2000; Wiles et al., 2006; Yoshizumi et al., 2004).

Third, the presence of auditory hallucinations was assessed with the question “Have you ever heard voices other people cannot hear?” Although it could be argued that some subjects may have reported the

same lifetime auditory hallucinatory experience at both time points, the analyses nevertheless suggest that "persistence" as assessed in the current study still represents a valid and good measure to predict true persistence, as prevalence (Dhossche et al., 2002; Escher et al., 2002b; Mcgee et al., 2000; Yoshizumi et al., 2004) and persistence rates (Escher et al., 2002b) of auditory hallucinations are in line with percentages found in other studies. Moreover, when filling in a questionnaire, subjects mostly tend to remember and thus to report the most recent event or experience.

**Role of funding source**

Funding for this study was provided by Maastricht University.

**Contributors**

Nicole Gunther, Marjan Drukker, Frans Ferron and Jim van Os designed the study. Nicole Gunther, Marjan Drukker and Frans Ferron were involved in data-collection. Ellen DeLoore, Marjan Drukker and Inez Myin-Germeys undertook the statistical analyses. Ellen DeLoore and Nicole Gunther wrote the first draft of the manuscript. Dirk Deboutte, Bernard Sabbe, Jim van Os and Inez Myin-Germeys supervised the writing of the manuscript. All authors contributed to and have approved the final manuscript.

**Conflict of interest**

All authors declare that they have no conflict of interest.

**Acknowledgements**

There are no acknowledgements.

## References

APA, 1980. Diagnostic and statistical manual of mental disorders, Third Edition. American Psychiatric Association, Washington, DC.

Askenazy, F.L., Lestideau, K., Meynadier, A., Dor, E., Myquel, M., Lecrubier, Y., 2007. Auditory hallucinations in pre-pubertal children. A one-year follow-up, preliminary findings. Eur. Child Adolesc. Psychiatry 16, 411–415.

Bak, M., Myin-Germeys, I., Hanssen, M., Bijl, R., Vollebergh, W., Delespaul, P., Van Os, J., 2003. When does experience of psychosis result in need for care? A prospective general population study. Schizophr. Bull. 29, 349–358.

Barkus, E., Murray, R.M., 2010. Substance use in adolescence and psychosis: clarifying the relationship. Annu. Rev. Clin. Psychol. 6, 365–389.

Bartels-Velthuis, A.A., Jenner, J.A., Van De Willige, G., Van Os, J., Wiersma, D., 2010. Prevalence and correlates of auditory vocal hallucinations in middle childhood. Br. J. Psychiatry 196, 41–46.

Becker, A., Hagenberg, N., Roessner, V., Woerner, W., Rothenberger, A., 2004. Evaluation of the self-reported sdq in a clinical setting: do self-reports tell us more than ratings by adult informants? Eur. Child Adolesc. Psychiatry 13 (Suppl 2), II17–II24.

Bentall, R.P., Corcoran, R., Howard, R., Blackwood, N., Kinderman, P., 2001. Persecutory delusions: a review and theoretical integration. Clin. Psychol. Rev. 21, 1143–1192.

Clayton, D., Hills, M., 1993. Wald tests. In: Hills, M., Clayton, D. (Eds.), Statistical models in epidemiology. Oxford Science Publications, Oxford.

Costello, A., Edelbrock, C., Kalas, R., Kessler, M., Klaric, C., 1982. Nimh diagnostic interview for children: child version. National Institute of Mental Health, Rockville: MD.

Cougnard, A., Marcelis, M., Myin-Germeys, I., De Graaf, R., Vollebergh, W., Krabbendam, L., Lieb, R., Wittchen, H.U., Henquet, C., Spauwen, J., Van Os, J., 2007. Does normal developmental expression of psychosis combine with environmental risk to cause persistence of psychosis? A psychosis proneness–persistence model. Psychol. Med. 37, 513–527.

Dhossche, D., Ferdinand, R., Van Der Ende, J., Hofstra, M.B., Verhulst, F., 2002. Diagnostic outcome of self-reported hallucinations in a community sample of adolescents. Psychol. Med. 32, 619–627.

Dominguez, M.D., Can Saka, M., Lieb, R., Wittchen, H.U., Van Os, J., 2010. Early expression of negative/disorganized symptoms predicting psychotic experiences and subsequent clinical psychosis: a 10-year study. Am. J. Psychiatry 167, 1075–1082.

Dominguez, M.D., Wichers, M., Lieb, R., Wittchen, H.U., Van Os, J., 2011. Evidence that onset of clinical psychosis is an outcome of progressively more persistent subclinical psychotic experiences: an 8-year cohort study. Schizophr. Bull. 37, 84–93.

Drukker, M., Wojciechowski, F., Feron, F.J., Mengelers, R., van Os, J., 2009. A community study of psychosocial functioning and weight in young children and adolescents. Int. J. Pediatr. Obes. 4, 91–97.

Escher, S., Delespaul, P., Romme, M., Buiks, A., Van Os, J., 2003. Coping defence and depression in adolescents hearing voices. J. Ment. Health 12, 91–99.

Escher, S., Morris, M.A.B., Delespaul, P., Van Os, J., Romme, M., 2004. Determinants of outcome in the pathways through care for children hearing voices. Int. J. Soc. Wefare 13, 208–222.

Escher, S., Romme, M., Buiks, A., Delespaul, P., Van Os, J., 2002a. Formation of delusional ideation in adolescents hearing voices: a prospective study. Am. J. Med. Genet. 114, 913–920.

Escher, S., Romme, M., Buiks, A., Delespaul, P., Van Os, J., 2002b. Independent course of childhood auditory hallucinations: a sequential 3-year follow-up study. Br. J. Psychiatry Suppl. 43, s10–s18.

Garety, P.A., Kuipers, E., Fowler, D., Freeman, D., Bebbington, P.E., 2001. A cognitive model of the positive symptoms of psychosis. Psychol. Med. 31, 189–195.

Goodman, R., 1997. The strengths and difficulties questionnaire: a research note. J. Child Psychol. Psychiatry 38, 581–586.

Gunther, N., Slavenburg, B., Feron, F., Van Os, J., 2003. Childhood social and early developmental factors associated with mental health service use. Soc. Psychiatry Psychiatr. Epidemiol. 38, 101–108.

Hanssen, M., Bak, M., Bijl, R., Vollebergh, W., Van Os, J., 2005. The incidence and outcome of subclinical psychotic experiences in the general population. Br. J. Clin. Psychol. 44, 181–191.

Kelleher, I., Harley, M., Murtagh, A., Cannon, M., 2009. Are screening instruments valid for psychotic-like experiences? A validation study of screening questions for psychotic-like experiences using in-depth clinical interview. Schizophr. Bull. doi:10.1093/sbp057.

Krabbendam, L., Myin-Germeys, I., Hanssen, M., Bijl, R.V., De Graaf, R., Vollebergh, W., Bak, M., Van Os, J., 2004. Hallucinatory experiences and onset of psychotic disorder: evidence that the risk is mediated by delusion formation. Acta Psychiatr. Scand. 110, 264–272.

Mackie, C.J., Castellanos-Ryan, N., Conrod, P.J., 2010. Developmental trajectories of psychotic-like experiences across adolescence: impact of victimization and substance use. Psychol. Med. 41, 47–58.

Maher, B.A., 1974. Delusional thinking and perceptual disorder. J. Individ. Psychol. 30, 98–113.

Maher, B.A., 2006. The relationship between delusions and hallucinations. Curr. Psychiatry Rep. 8, 179–183.

Mcgee, R., Williams, S., Poulton, R., 2000. Hallucinations in nonpsychotic children. J. Am. Acad. Child Adolesc. Psychiatry 39, 12–13.

Minozzi, S., Davoli, M., Bargagli, A.M., Amato, L., Vecchi, S., Perucci, C.A., 2010. An overview of systematic reviews on cannabis and psychosis: discussing apparently conflicting results. Drug Alcohol Rev. 29, 304–317.

Morrison, A.P., 2001. The interpretation of intrusions in psychosis: an integrative cognitive approach to hallucinations and delusions. Behav. Cogn. Psychother. 29, 257–276.

Ohayon, M.M., 2000. Prevalence of hallucinations and their pathological associations in the general population. Psychiatry Res. 97, 153–164.

Polanczyk, G., Moffitt, T.E., Arseneault, L., Cannon, M., Ambler, A., Keefe, R.S., Houts, R., Odgers, C.L., Caspi, A., 2010. Etiological and clinical features of childhood psychotic symptoms: results from a birth cohort. Arch. Gen. Psychiatry 67, 328–338.

Poulton, R., Caspi, A., Moffitt, T.E., Cannon, M., Murray, R., Harrington, H., 2000. Children's self-reported psychotic symptoms and adult schizophreniform disorder: a 15-year longitudinal study. Arch. Gen. Psychiatry 57, 1053–1058.

Preti, A., Bonventre, E., Ledda, V., Petretto, D.R., Masala, C., 2007. Hallucinatory experiences, delusional thought proneness, and psychological distress in a nonclinical population. J. Nerv. Ment. Dis. 195, 484–491.

Rossler, W., Riecher-Rossler, A., Angst, J., Murray, R., Gamma, A., Eich, D., Van Os, J., Gross, V.A., 2007. Psychotic experiences in the general population: a twenty-year prospective community study. Schizophr. Res. 92, 1–14.

Schreier, H.A., 1999. Hallucinations in nonpsychotic children: more common than we think? J. Am. Acad. Child Adolesc. Psychiatry 38, 623–625.

Smeets, F., Lataster, T., Dominguez, M., Hommes, J., Lieb, R., Wittchen, H.U., Van Os, J., in press. Evidence that onset of psychosis in the population reflects early perceptual anomalies that through environmental risks and affective dysregulation secondarily become complicated by delusions. Schizophrenia Bulletin. doi:10.1093/sbq117.

Statacorp, 2009. Stata statistical software: Release 11. College Station, Texas.

Tien, A.Y., 1991. Distributions of hallucinations in the population. Soc. Psychiatry Psychiatr. Epidemiol. 26, 287–292.

Van Os, J., Hanssen, M., Bijl, R.V., Ravelli, A., 2000. Strauss (1969) revisited: a psychosis continuum in the general population? Schizophr. Res. 45, 11–20.

Van Os, J., Linscott, R.J., Myin-Germeys, I., Delespaul, P., Krabbendam, L., 2009. A systematic review and meta-analysis of the psychosis continuum: evidence for a psychosis proneness-persistence-impairment model of psychotic disorder. Psychol. Med. 39, 179–195.

Van Rossum, I., Dominguez, M., Lieb, R., Wittchen, H.-U.,Van Os, J., in press. Affective dysregulation and reality distortion: a 10-year prospective study of their association and clinical relevance. Schizophrenia Bulletin. doi:10.1093/sbp101.

Verdoux, H., Van Os, J., Maurice-Tison, S., Gay, B., Salamon, R., Bourgeois, M., 1998. Is early adulthood a critical developmental stage for psychosis proneness? A survey of delusional ideation in normal subjects. Schizophr. Res. 29, 247–254.

Wiles, N.J., Zammit, S., Bebbington, P., Singleton, N., Meltzer, H., Lewis, G., 2006. Self-reported psychotic symptoms in the general population: results from the longitudinal study of the British national psychiatric morbidity survey. Br. J. Psychiatry 188, 519–526.

Yoshizumi, T., Murase, S., Honjo, S., Kaneko, H., Murakami, T., 2004. Hallucinatory experiences in a community sample of Japanese children. J. Am. Acad. Child Adolesc. Psychiatry 43, 1030–1036.