The association between sleep quality and attenuated psychotic symptoms

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Abstract
Aim: To determine if poor sleep makes a unique contribution in predicting the likelihood of experiencing six or more attenuated psychotic symptoms and associated distress, after examining and controlling for sociodemographic factors, depression and drug/alcohol use.

Method: An online survey was conducted using Amazon’s online crowdsourcing service Mechanical Turk (MTurk). The sample was 1013 adults (18 to 36 years) from the general population in the United States. The survey consisted of the Prodromal Questionnaire 16 (PQ-16), the Pittsburgh Sleep Quality Index, the Patient Health Questionnaire 9, the Drug Abuse Screening Test 10 and the Alcohol Use Disorders Identification Test. Regression analyses were performed with the PQ-16 as the dependent variable, and sleep quality as the predictor variable, holding constant sociodemographic variables, depression, and alcohol/drug abuse.

Results: 37% of the sample endorsed six or more PQ-16 items, which may be suggestive of an at-risk mental state, with sleep disturbance significantly increasing the likelihood (Odds ratio 2.09 < .001) of endorsing six or more PQ-16 items. After controlling for sociodemographic variables, depression and drug/alcohol abuse, poor sleep quality made a unique contribution of 5.8% of the variance accounted for in level of distress experienced by attenuated psychotic symptoms.

Conclusion: Effective treatment of sleep disturbance may reduce the likelihood of experiencing attenuated psychotic symptoms and associated distress.

Keywords
at-risk mental state, depressive symptoms, psychotic symptoms, sleep disturbance

INTRODUCTION

As 20% to 45% of individuals with an At-Risk Mental State (ARMS) transition to psychosis (Nelson, Yung, Bechdolf, & McGorry, 2008; Oliver et al., 2019), it is important to investigate factors included in the ARMS criteria. The present study focused on attenuated psychotic symptoms (APS) as they are present in both clinical settings and the general population (Bentall, Claridge, & Slade, 1989; Johns & van Os, 2001), suggesting that they may be an early indicator of psychosis risk. Mills, Fusar-Poli, Morgan, Azis, and McGuire (2017) found that 14.4% of 208 young adults in a community sample met ARMS criteria and concluded that there may be a large number of young
adults in the general population with an at-risk mental state; a conclusion supported by Mongan, Shannon, Hanna, Boyd, and Mulholland (2019) who reported 19% of participants in a community survey experiencing at least six attenuated psychotic symptoms, which may be suggestive of ARMS.

A meta-analysis of 26 factors concluded that APS met the level of highly suggestive evidence for transition to psychosis (Oliver et al., 2019). With APS possibly having such a role within the aetiology of psychosis, it is important to study factors involved in these symptoms. One factor associated with APS is poor sleep (Davies, Haddock, Yung, Mulligan, & Kyle, 2017). Although sleep dysfunction has been extensively researched in schizophrenia (for a review see: Robertson, Cheung, & Xiaoduo, 2019), any attempt to research potential aetiological factors requires examination of the earlier stages of psychosis development. A positive association between insomnia and paranoid experiences was reported in a community sample of 300 people (Freeman, Pugh, Vorontsova, & Southgate, 2009), whilst experimental sleep deprivation was found to induce perceptual distortions (Petrovsky et al., 2014). Sheaves et al. (2016) reported that insomnia was predictive of de novo hallucinations at 18-month follow-up, and Hennig and Lincoln (2018) found that shorter sleep predicted paranoia, but paranoia did not predict insomnia.

With poor sleep warranting examination as a potential precipitant of psychotic experiences, it is notable that only half of the 21 articles (many with small sample sizes) in a systematic review of sleep disturbance in early psychosis investigated sleep as a primary research question (Davies et al., 2017). The present study aimed to address these concerns by recruiting a large sample to investigate sleep as a primary research question, using the Pittsburgh Sleep Quality Index (PSQI). In a previous study using this measure, the mean total PSQI score in an ARMS group was 7.7 vs 4.95 in healthy controls, where a score 5 or more is indicative of poor sleep (Castro et al., 2015). However, it was not possible to determine which areas of sleep dysfunction participants experienced, as only mean PSQI total scores were reported.

Conversely, when Lunsford-Avery, LeBourgeois, Gupta, and Mittal (2015) compared healthy controls and an ARMS group, they did not report mean total PSQI scores, but reported that after controlling for medication, age and depression, the ARMS group had higher sleep latency scores. This study also found that sleep disturbance predicted positive symptoms in the ARMS group and the authors concluded that sleep disturbance may be important in the pathogenesis of psychosis. Identifying such specific areas of sleep dysfunction associated with APS is important if clinical interventions are to be developed to improve sleep and reduce APS. Andorko et al. (2017) was reportedly the first study to find a relationship between a broad range of sleep difficulties and a comprehensive range of APS. Fragmented sleep, night anxiety and sleep hallucination significantly predicted APS. This study also examined distress related to APS, which is important given that cognitive models of psychosis (e.g., Garety, Kuipers, Fowler, Freeman, & Bebbington, 2001) posit that it is the distress associated with APS that leads to a need for care, rather than APS per se (Ward et al., 2014). This highlights the value of establishing if poor sleep plays a role in the distress associated with APS. Andorko et al. (2017) found that initial insomnia, night anxiety, movements at night, sensations at night, and sleep hallucination predicted APS related distress. However, this study’s sample was 409 college students and, although this age group is at the peak of psychosis onset, the findings could not be generalized beyond college students.

The present study aimed to extend this research by using a larger sample with a broader age range and educational/occupational backgrounds that may be more representative of the general population. Additionally, the study by Andorko et al. (2017) did not measure if poor sleep increased the likelihood of experiencing a level of APS that may be suggestive of ARMS. When investigating the validity of a 16-item version of the Prodromal Questionnaire in the general population, Ising et al. (2012) found that endorsing six or more items produced correct classification of an ARMS profile in 44% of cases. Therefore, establishing which sleep problems increase the likelihood of experiencing six or more APS may be clinically important. Before estimating any of the effects outlined above, it is necessary to consider the factors below which are known to be related to APS, so that their effects may be examined and controlled for.

### 1.1 Socio-demographic factors

Whilst age is an inverse predictor of APS, individuals with lower educational attainment are more likely to endorse APS and females are more likely to have severe distress ratings (Gaudiano & Zimmerman, 2013; Waford et al., 2015). Although individuals from ethnic minorities tend to endorse more APS (Gaudiano & Zimmerman, 2013) and are more likely to develop an ARMS profile (Velthorst et al., 2012), having a strong identity with an ethnic minority group may serve as a protective factor against APS (Anglin, Lui, Espinosa, Tikhonov, & Ellman, 2018). It is also possible that socio-demographic factors interact with sleep to confer risk for APS, when considering that a Finnish study found that insomnia was more common in women, and was more likely to be associated with those who were not married, had no children, had low education, low income and who were unemployed (Ohayon & Schatzberg, 2002).

### 1.2 Depression

In their study of causal associations between depressive symptoms and schizophrenia, Häfner, Maurer, Trendler, an der Heide, Schmidt and Könnecke (2005) recruited 232 patients presenting with a first episode of psychosis and compared their symptoms with a group of 130 demographically matched depressed patients and a group of 130 healthy controls. In those diagnosed with psychosis, depressed mood was the most frequent initial presentation, appearing 4 years before first admission to hospital with psychosis. The two patient groups only differentiated from the depressive core syndrome as the psychosis group began to experience more
positive symptoms approaching admission to hospital. The authors concluded that depression might be an early stage of the same neurobiological processes that are involved in psychosis onset. When considering this possibility, it must be remembered that the relationship between sleep and depression is complex. For example, insomnia confers a higher risk for depression, but depression is also a risk factor for developing insomnia (Ohayon & Schatzberg, 2002), so depression and poor sleep may interact to increase risk of APS.

1.3 | Drug and alcohol abuse

Drug and alcohol abuse is prevalent among people diagnosed with psychotic disorders (Merikangas & McClair, 2012; Moore, Mancuso, Slade, Galletly, & Castle, 2012). A study by Sivertsen, Skogen, Jakobsen, and Hysing (2016) found a dose-response between drug and alcohol use and sleep disturbance. In the general population, APS are more prevalent in cannabis users vs non-users (Ruiz-Veguilla et al., 2013; van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009), with suggestions that its use may have psychotogenic effects (Corcoran et al., 2008). Additionally, a large scale general population study of 10 200 Norwegian young people (16-19) found a dose-dependent relationship between drug and alcohol use and sleep disturbance (Siversten et al., 2016).

1.4 | The present study

The present study sought to extend research with adolescents and college students by recruiting a large community sample to establish if there is a significant number of young adults in the general population with a potential ARMS profile, and examine which areas of poor sleep are predictive of endorsing six or more of APS and associated distress after controlling for potential confounding factors. The hypotheses were:

Hypothesis 1 Previous findings will be replicated with between 14% and 19% of individuals in this large community sample endorsing six or more APS.

Hypothesis 2 Socio-demographic factors, depression, and drug/alcohol abuse will each make a unique contribution to the likelihood of participants endorsing six or more APS but, after controlling for these effects, PSQI subscales (eg, sleep latency, sleep disturbance) will further increase the likelihood of participants endorsing six or more APS.

Hypothesis 3 Socio-demographic factors, depression, and drug/alcohol abuse will each make a unique contribution to predicting APS-related distress but, after controlling for these effects, poor sleep will further predict increased APS-related distress levels.

2 | METHOD

2.1 | Participants

Participants were recruited from Mechanical Turk (MTurk), an Internet-based crowd sourcing service offering users to register as a “worker” with the site and receive payment for completing “human intelligence tasks” (HITs); a broad range of tasks including answering questionnaires. Although MTurk workers self-select to the platform there are controls to define which “workers” are suitable for a given HIT. In a 2018 ecological analysis, which sampled 40 000 unique MTurk participants, Difallah and colleagues identified an increased proportion of female MTurk users among the US MTurk population (55% female among US users vs 51% female across all countries). MTurk users tend to have a lower mean age than the general population. For the purposes of the present study, which sought to examine the under-35s population given the general demographics of those with an ARMS, this is an advantage.

2.2 | Procedure

Data from approximately 1000 participants was collected over 4 weeks to create a large database that is intended to be used to examine several other hypotheses in addition to those examined in the present study. A filter was applied so that only users with a 95% acceptability rating from previous HITs (ie, completed at least 95% of the HIT) could see the present study in MTurk. Participants read an information sheet with full details of the study, that is, the voluntary nature of participation, the right to withdraw, the type of information that would be asked (sleep pattern, depressive symptoms, APS etc.), how to contact the research team and information about remuneration, which would be processed using MTurk ID codes, with no personal information being stored or analysed. Anyone wishing to participate confirmed their wish to do so by completing the HIT, on the understanding that doing so confirmed that they had understood the information sheet, that they were willing to be a participant, and that they agreed to anonymous data being used in scientific analysis and publication. Upon satisfactory completion of the survey, participants were paid approximately $2.00. Incomplete data was rejected, whilst anonymous data from completed HITs was exported to an MS Excel spreadsheet for scoring, before being exported to SPSS (Version 25) for analysis.

2.3 | Measures

Participants were asked to provide socio-demographic data, namely: age, sex, marital status, employment status and education level before being asked to complete the questionnaires below. Five attention questions were embedded within the questionnaires; an example being, “I eat for more than 25 hours per day: True/False/Unsure.”
2.3.1 | The Prodromal Questionnaire (PQ-16)

The PQ-16 is a self-report measure for screening unusual experiences (APS) associated with the psychosis prodrome. The subscales consist of perceptual abnormalities/hallucinations (9 items), unusual thought content/delusional ideas/paranoia (5 items) and two items related to negative symptoms. It has high sensitivity (87%) and specificity (87%) in distinguishing between meeting criteria and not meeting criteria for having an ARMS, as assessed using the Comprehensive Assessment of At-Risk Mental State, and has good internal consistency with Cronbach’s α = .8 (Ising et al., 2012). The presence of APS is assessed as “true/false,” with items endorsed then measuring distress on a 4-point scale (no distress, mild, moderate and severe distress). The total score is achieved by adding up all true items (possible range: 0-16), with total scores of six or more being suggestive of an at-risk mental state (Ising et al., 2012), whilst the total distress score was the sum of the distress scales (possible range: 0-48).

2.3.2 | Pittsburgh Sleep Quality Index (PSQI)

The PSQI is a 19-item self-report questionnaire with seven subscales (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, day-time function and use of medication) with good internal consistency (Cronbach’s α = .83), good test-retest reliability and good validity (Buysse, Reynolds 3rd, Monk, Berman, & Kupfer, 1989). Scoring is on a 0 to 3 scale, with 0 indicating no difficulty and 3 indicating severe difficulty. A total score is achieved by summing all items (range: 0-21), with “good sleepers” being differentiated from “poor sleepers” at the cut-off score of 6 (Buysse et al., 1989).

2.3.3 | Patient Health Questionnaire 9 (PHQ-9)

The PHQ-9 is a self-report questionnaire used to assess the presence and severity of depressive symptoms in the 2 weeks prior to its completion, with good internal consistency (Cronbach’s α = .89) found in 3000 primary care patients, and criterion validity having 88% sensitivity and 88% specificity when measuring PHQ-9 scores from 580 participants against depression diagnoses validated by a mental health professional (Kroenke, Spitzer, & Williams, 2001). Scores range from 0 to 27.

2.3.4 | Alcohol Use Disorders Identification Test (AUDIT)

The AUDIT was developed by the World Health Organization and has been validated globally. A review showed that it has a median reliability coefficient of 0.83 across 18 studies (Reinert & Allen, 2007). It is a 10-item scale assessing alcohol consumption and related problems, with suggested cutoff scores of 8 distinguishing harmful users and 11 classifying alcohol dependence (Tsai, Tsai, Chen, & Liu, 2005). Scores range from 0 to 40.

2.3.5 | Drug Abuse Screening Test 10 (DAST-10)

The DAST-10 is a self-report scale examining problematic substance use which has been used across a number of participant groups. It has good internal consistency (Cronbach’s alpha approaching .9) (Yudko, Lozhkina, & Fouts, 2007). Sensitivity and specificity was found to be .98 and .91 respectively, when using 4 as the cut-off point (Evren, Ovali, Karabulut, & Cetingok, 2014). Scores range from 0 to 10.

2.4 | Data analysis

Cases with missing data or incorrect answers to the attention questions were removed before data analyses were performed on IBM SPSS Statistics. To facilitate calculation of the percentage of participants endorsing six or more APS and logistic regression analysis, the PQ-16 total score was dichotomized into two groups; those endorsing six or more items (suggestive of ARMS) vs those endorsing five or fewer PQ-16 items. Tests for normal distribution were conducted to ensure that this assumption was met for parametric analyses. Residual and scatter plots were inspected to ensure that the assumptions of normality, linearity and homoscedasticity were met, whilst inspection of variance inflation factor (VIF) and Tolerance indicated that multicollinearity was not an issue, and Cook’s distance values indicated that there were no influential outliers.

Hierarchical logistic regression analysis was performed to examine if poor sleep quality increased the likelihood of endorsing six or more PQ-16 items when controlling for demographic factors, depression, and drug/alcohol abuse. Hierarchical multiple regression analyses were completed to calculate if poor sleep quality predicted APS distress level when controlling for socio-demographic factors, depression and drug/alcohol abuse.

3 | RESULTS

After rejecting incomplete cases (n = 52) and those with incorrect answers to attention questions (n = 2), the total sample analysed consisted of 1013 participants. Socio-demographic information is presented in Table 1.

The internal consistencies (Table 2) of the PQ-16, PHQ-9 and the DAST-10 were excellent and the internal consistencies of the PSQI and the AUDIT were approaching excellent. The mean total score for the PSQI was above 6 which has been found to differentiate good and poor sleepers. The mean total score for the PHQ-9 is within the mild depressive symptoms range, whereas the mean score of 5.08 on the PQ-16 was below the cut-off score of 6 that has been found to be suggestive of ARMS (Ising et al., 2012). The mean score
for the DAST-10 was 5.39, which is above the suggested cut-off point of 4 (Evren et al., 2014), whilst the mean score for the AUDIT (4.63) is below the suggested cut-off for harmful use (Tsai et al., 2005).

### Table 1: Demographic information of sample (n = 1013)

| Demographic                  | Percentage |
|------------------------------|------------|
| Mean age (SD)                | 29.7 (3.83)|
| Gender                       |            |
| Female                       | 50.9       |
| Male                         | 49.1       |
| Relationship status (%)      |            |
| Single, never married        | 45.1       |
| Married                      | 34.4       |
| Single, but cohabiting with partner | 14.2   |
| Domestic partnership/civil union | 4.2 |
| Divorced                     | 1.2        |
| Separated                    | .8         |
| Widowed                      | .1         |
| Education (%)                |            |
| Bachelor degree              | 43.2       |
| Some college but no degree   | 20.4       |
| Graduate degree              | 14.3       |
| Associate degree             | 11.2       |
| High school degree or equivalent | 10.5 |
| Less than high school        | .4         |
| Employment status (%)        |            |
| Employed full-time           | 70.3       |
| Employed part-time           | 17.1       |
| Not employed, seeking work   | 6.1        |
| Not employed, not seeking work| 5.9   |
| Retired                      | .6         |
| Disabled, not able to work   | 0          |
| Ethnicity (%)                |            |
| White/Caucasian              | 76         |
| Asian/Pacific Islander       | 9.2        |
| Hispanic                     | 5.9        |
| Black or African American    | 5.4        |
| Multiple ethnicity           | 2.8        |
| American Indian/Native Alaskan | .7 |

### Hypothesis 1

More than a third (37%) of the sample endorsed six or more PQ-16 items. Table 3 shows the mean number of APS endorsed was 5.08 and the full range of items (0-16) was achieved. Almost 10% of individuals reported zero APS. The modal number of items endorsed was two. Of the 90.3% of individuals endorsing at least one PQ-16 item, the most frequently endorsed was intense anxiety when meeting people for the first time.

Table 4 shows the full range of scores was achieved for all subscales of the PSQI. Almost a third of participants regularly took up to 30 minutes to fall asleep. Two-thirds of the sample reported sleeping between 5 and 7 hours per night, which is below the recommended 7 to 9 hours sleep recommended for optimal health (Walker, 2017).

### Hypothesis 2

Table 5 shows the first hierarchical logistic regression model, which was statistically significant ($\chi^2[6] = 17.98, P = .006$), with socio-demographic variables accounting for 2.4% (Nagelkerke $R^2$) of the variance in the likelihood of endorsing six or more PQ-16 items. Only one socio-demographic variable reached significance; higher education predicted a lower likelihood of endorsing six or more PQ-16 items. After entering PHQ-9 total score, the second model accounted for a further 26.6% of the variance explained and increasing PHQ-9 scores increased the likelihood (Odds Ratio 1.21, $P < .001$) of endorsing six or more PQ-16 items. Adding DAST-10 and AUDIT scores in the third step only accounted for a further 1.5% of variance explained by the model, with only the DAST-10 scores making a statistically significant difference; however, given that the DAST-10 does not specify what type of substance was used by participants, interpretation of results related to the DAST-10 is limited.

The final model accounted for a total of 36.8% of variance, with the components of the PSQI having a unique contribution of 6.3% when all other variables were held constant. The sleep disturbance subscale had the largest effect, with higher scores on this scale predicting a higher likelihood of endorsing six or more PQ-16 items.

### Hypothesis 3

Table 6 shows the first hierarchical multiple regression model, which was significant ($F[61006] = 6.37; P < .001$), accounting for 3.1% of the variance in PQ-16 distress score, with age and education being the
only significant (negative) predictors. The effect size of the first model was small (Cohen's $f^2 = .04$). Adding PHQ-9 scores resulted in a further 38.6% of the variance ($F[11005] = 104.26; P < .001$), whilst entering drug/alcohol abuse in the third model accounted for a further 1.6% ($F[21003] = 87.02; P < .001$). The final model, with the components of the PSQI included, explained a total 49.1% of the variance of PQ-16 distress scores ($F[7996] = 62.02; P < .001$), with the components of the PSQI accounting for 5.8% unique variance in the model. The final model had a large effect size (Cohen's $f^2 = .99$). Subjective sleep quality and habitual sleep efficiency significantly predicted (negatively) PQ-16 distress. Sleep duration, sleep disturbance, use of sleep medication and daytime dysfunction all significantly positively predicted PQ-16 distress score, with sleep disturbance having the largest effect.

### TABLE 3 Descriptive statistics for PQ-16 responses

| PQ-16 item                                  | Percentage endorsing item | Total number of items endorsed | Percentage endorsed |
|---------------------------------------------|---------------------------|-------------------------------|--------------------|
| Anxiety meeting new people                  | 69.5                      | 0                             | 9.7                |
| Lack of interest                            | 55.9                      | 1                             | 11.6               |
| Déjà vu                                     | 52.4                      | 2                             | 11.9               |
| Hearing own thoughts                        | 36.3                      | 3                             | 11.7               |
| Distraction by distant sounds               | 33.5                      | 4                             | 10.3               |
| Auditory hallucinations                     | 32.4                      | 5                             | 7.7                |
| Confusing differentiating reality           | 30.8                      | 6                             | 6.6                |
| Unable to control thoughts                  | 30.7                      | 7                             | 5.8                |
| Olfactory/taste hallucinations              | 30.4                      | 8                             | 3.8                |
| Inferring meaning                           | 24.8                      | 9                             | 4.4                |
| Sensing invisible force                     | 24.6                      | 10                            | 4.5                |
| Paranoia                                    | 24.2                      | 11                            | 2.6                |
| Sensing bodily changes                      | 23.4                      | 12                            | 1.4                |
| Visual hallucination                        | 15.5                      | 13                            | .8                 |
| Hearing voices                              | 14.5                      | 14                            | 2.5                |
| Facial hallucination                        | 9.4                       | 15                            | 1.1                |

### TABLE 4 Descriptive statistics for PSQI subscales

| PSQI subscale                  | Percentage of items endorsed |
|-------------------------------|------------------------------|
| Sleep latency                 |                              |
| Up to 15 minutes              | 19.5%                        |
| 16 to 30 minutes              | 29.0%                        |
| 31 to 60 minutes              | 25.2%                        |
| More than 60 minutes          | 26.3%                        |
| Subjective sleep quality      |                              |
| Very good                     | 8.0%                         |
| Fairly good                   | 45.0%                        |
| Fairly bad                    | 41.8%                        |
| Very bad                      | 5.2%                         |
| Sleep disturbance             |                              |
| No problem at all             | 4.9%                         |
| Very slight problem           | 69%                          |
| Somewhat of a problem         | 24.3%                        |
| A very big problem            | 1.8%                         |
| Sleep duration                |                              |
| More than 7 hours             | 28.3%                        |
| 6 to 7 hours                  | 31.0%                        |
| 5 to 6 hours                  | 33.5%                        |
| Fewer than 5 hours            | 7.2%                         |
| Daytime dysfunction           |                              |
| No problem at all             | 51.1%                        |
| Very slight problem           | 24.7%                        |
| Somewhat of a problem         | 16.6%                        |
| A very big problem            | 7.6%                         |
| Sleep efficiency              |                              |
| Greater than 85%              | 58.1%                        |
| 75% to 84%                    | 21.6%                        |
| 65% to 74%                    | 9.7%                         |
| Less than 65%                 | 10.6%                        |
| Use of sleep medication       |                              |
| Not during past month         | 73.5%                        |
| Less than once a week         | 9.1%                         |
| Once or twice a week          | 7.5%                         |
| Three or more per week        | 9.9%                         |

4 | DISCUSSION

The present study sought to extend research with adolescents and college students by recruiting a large community sample to establish if there is a significant number of young adults in the general population with a potential ARMS profile, and examine which areas of poor sleep are predictive of endorsing six or more of APS and associated distress after controlling for potential confounding factors. This was achieved by using an Internet-based crowd sourcing service to recruit a large sample from the general population. Thirty-seven percent of young adults in the present study endorsed six or more items on the PQ-16, which Ising et al. (2012) report may be suggestive of ARMS. This percentage is significantly higher than found previously (eg, Mongan et al., 2019; van Os et al., 2009) and may be due to self-selection bias (see limitations below).

Although gender, ethnicity and employment status did not significantly predict the likelihood of endorsing at least six PQ-16 items or distress, increasing age and level of education was associated with
### Table 5

Logistic regression models for predictors of endorsing six or more PQ16 items

| Model | $R^2$ (Nagelkerke) | $\chi^2$ (df) | P | Beta | 95% Confidence Interval |
|-------|-------------------|---------------|---|------|-------------------------|
| **Model 1** | 2.4% | 17.98, P = .006 | | | **Age** | −.01 | .96 | .99 | 1.03 | .714 |
| | | | | | **Gender** | −.18 | .64 | .84 | 1.09 | .185 |
| | | | | | **Marital status** | .01 | .96 | 1.01 | 1.06 | .788 |
| | | | | | **Education** | −.16 | .77 | .85 | .95 | .003 |
| | | | | | **Employment status** | .11 | .96 | 1.11 | 1.28 | .151 |
| | | | | | **Ethnicity** | .06 | .93 | 1.06 | 1.21 | .356 |
| **Model 2** | 29% | 241.85, P < .001 | | | **Age** | .01 | .97 | 1.01 | 1.05 | .769 |
| | | | | | **Gender** | .23 | .93 | 1.26 | 1.71 | .144 |
| | | | | | **Marital status** | −.03 | .91 | .93 | 1.02 | .248 |
| | | | | | **Education** | −.08 | .82 | .93 | 1.05 | .228 |
| | | | | | **Employment status** | −.01 | .84 | .99 | 1.17 | .892 |
| | | | | | **Ethnicity** | .04 | .90 | 1.04 | 1.21 | .576 |
| | | | | | **PHQ-9 score** | .19 | 1.18 | 1.21 | 1.25 | <.001 |
| **Model 3** | 30.5% | 256.08, P < .001 | | | **Age** | .01 | .97 | 1.01 | 1.05 | .741 |
| | | | | | **Gender** | .18 | .87 | 1.21 | 1.63 | .263 |
| | | | | | **Marital status** | −.03 | .91 | .97 | 1.03 | .285 |
| | | | | | **Education** | −.07 | .82 | .93 | 1.05 | .247 |
| | | | | | **Employment status** | .15 | .86 | 1.01 | 1.21 | .859 |
| | | | | | **Ethnicity** | .03 | .89 | 1.03 | 1.21 | .691 |
| | | | | | **PHQ-9 score** | .19 | 1.17 | 1.21 | 1.24 | <.001 |
| | | | | | **DAST-10 score** | .08 | 1.03 | 1.08 | 1.13 | .001 |
| | | | | | **AUDIT score** | .02 | .99 | 1.02 | 1.06 | .141 |
| **Model 4** | 36.8% | 307.16, P < .001 | | | **Age** | −.01 | .95 | .99 | 1.04 | .730 |
| | | | | | **Gender** | .21 | .89 | 1.24 | 1.71 | .205 |
| | | | | | **Marital status** | −.01 | .93 | .99 | 1.01 | .699 |
| | | | | | **Education** | −.07 | .82 | .93 | 1.06 | .277 |
| | | | | | **Employment status** | .01 | .84 | .98 | 1.19 | .981 |
| | | | | | **Ethnicity** | .04 | .89 | 1.04 | 1.22 | .606 |
| | | | | | **PHQ-9 score** | .14 | 1.11 | 1.16 | 1.21 | <.001 |
| | | | | | **DAST-10 score** | .08 | 1.03 | 1.09 | 1.13 | .001 |
| | | | | | **AUDIT score** | .01 | .98 | 1.01 | 1.05 | .483 |
| | | | | | **Subj. sleep qual.** | −.56 | .43 | .58 | .78 | <.001 |
| | | | | | **Sleep latency** | .03 | .87 | 1.03 | 1.22 | .756 |

(Continues)
### TABLE 5 (Continued)

| Model 4 | 95% Confidence Interval |
|---------|-------------------------|
| $R^2 = 36.8\%$ (Nagelkerke); $\chi^2(16) = 307.16, P < .001$ | Beta Lower Odds Ratio Upper $P$ |
| Sleep duration | .46 | 1.23 | 1.51 | 1.86 | <.001 |
| Sleep efficiency | −.14 | .72 | .87 | 1.05 | .137 |
| Sleep disturbance | .74 | 1.49 | 2.09 | 2.93 | <.001 |
| Sleep medication | .16 | 1.00 | 1.17 | 1.37 | .050 |
| Daytime dysfunction | .32 | 1.11 | 1.37 | 1.69 | .003 |

### TABLE 6 Regression models for predictors of PQ16 distress score

#### Model 1. Predictors: Demographic variables

| Beta | Standardized B | t | P |
|------|----------------|---|---|
| Age | −.24 | −.09 | −2.87 | .004 |
| Gender | −1.47 | −.08 | −2.38 | .017 |
| Marital Status | −.09 | −.03 | −.77 | .439 |
| Education | −.81 | −.11 | −3.25 | .001 |
| Employment | .56 | .05 | 1.63 | .103 |
| Ethnicity | .41 | .04 | 1.37 | .171 |

#### Model 2. Predictors: Demographic variables and PHQ9 score

| Beta | Standardized B | t | P |
|------|----------------|---|---|
| Age | −.17 | −.07 | −2.62 | .009 |
| Gender | .80 | −.04 | 1.64 | .10 |
| Marital Status | −.064 | −.018 | −.68 | .50 |
| Education | −.20 | −.03 | −1.03 | .31 |
| Employment | −.19 | −.02 | −.74 | .46 |
| Ethnicity | .21 | .02 | .89 | .37 |
| PHQ-9 score | 1.04 | .65 | 25.81 | <.001 |

#### Model 3. Predictors: Demographic variables, PHQ-9, DAST-10, AUDIT

| Beta | Standardized B | t | P |
|------|----------------|---|---|
| Age | −.17 | −.07 | −2.65 | .008 |
| Gender | .46 | .02 | .95 | .34 |
| Marital Status | −.20 | −.03 | −1.05 | .29 |
| Education | −.29 | −.08 | −3.23 | .001 |
| Employment | −.01 | −.00 | −.03 | .987 |
| Ethnicity | .09 | .01 | .39 | .697 |
| PHQ-9 score | .99 | .61 | 23.66 | <.001 |
| DAST-10 score | .24 | .08 | 3.51 | <.001 |
| AUDIT | .21 | .11 | 4.35 | <.001 |

#### Model 4. Predictors: Demographic variables, PHQ9, AUDIT, DAST-10 and PSQI subscales

| Beta | Standardized B | t | P |
|------|----------------|---|---|
| Age | −.23 | −.09 | −3.71 | <.001 |
| Gender | .50 | .03 | 1.08 | .280 |
| Marital Status | −.25 | −.03 | 1.34 | .180 |
| Education | −.19 | −.06 | 2.24 | .026 |
lower likelihood of experiencing six or more APS in the first regression model, which is similar to previous research (Schultze-Lutter, Ruhrmann, Berning, Maier, & Klosterkoetter, 2010). However, none of the socio-demographic factors were significant when depression and drug/alcohol abuse were added to the models. Given that sleep difficulties are also related to gender, marital status, education level and income it may be that socio-demographic factors interact with sleep to confer risk for APS. Future research may be useful in investigating this.

Although the unique contribution (5.8%) made by the PSQI subscales was modest (compared to the contribution made by depression), it is noteworthy that the same three PSQI subscales predicted both the likelihood of endorsing at least six PQ-16 items and the level of distress experienced by these APS. Sleep disturbance had the largest effect, followed by sleep duration and daytime dysfunction. Future research examining the relationship between these three variables may lead to a better understanding of why they have such an effect of APS.

Whilst use of sleep medication also predicted PQ-16 distress score, it is interesting to note that two PSQI subscales (subjective sleep quality and habitual sleep efficiency) negatively predicted PQ-16 distress. This surprising finding suggests that participants who believed their sleep to be of poor quality and whose sleep was less efficient had lower distress; contrary to what might be expected. One possible reason is that participants may have underestimated their sleep efficiency and thus believed their sleep quality to be poorer than might have been found by objective measures (see limitations below).

4.1 | Implications

As well as supporting previous observational and experimental studies showing that sleep deprivation is predictive of perceptual distortions and hallucinations (Freeman et al., 2009; Petrovsky et al., 2014; Sheaves et al., 2016), the current study also found that poor sleep significantly predicted PQ-16 distress. One possible explanation for this is that poor sleep is known to contribute to more negative cognitive biases. For example, in a study by Gujar, McDonald, Nishida, and Walker (2011), healthy participants who had insufficient sleep demonstrated a fear bias in an emotional face recognition task. Additionally, cognitive processes involved in psychosis development, for example, jumping to conclusion bias (Garety et al., 2005) could be affected by sleep disturbance, although further work would be required to investigate this. Regarding specific components of sleep difficulty, sleep disturbance made the most significant contribution in both regression models. The subscale measuring sleep disturbance is composed of items related to sleep maintenance (eg, getting up to use the bathroom; being too cold/hot). From a clinical viewpoint, these difficulties may be easily ameliorated through fluid intake and temperature management.

The present findings support the suggestion by Mills et al. (2017) that there may be a large number of young adults in the general population with ARMS, and their recommendation for further investment in services aimed at psychosis prevention/early intervention is reiterated here. It is also recommended that such services routinely assess for sleep difficulties, which if treated early and effectively, may help prevent the worsening of symptoms and associated distress, thus potentially reducing development of an ARMS profile. For example, in a randomized control trial investigating the effects of improving sleep on mental health, participants whose sleep improved after completing a digital cognitive behaviour therapy intervention showed sustained reductions in paranoia and hallucinations (Freeman et al., 2017). Given that there are other well-established effective sleep interventions using traditional face-to-face CBT for insomnia (eg, Taylor & Puiksma, 2014) it could be a promising route of investigation if such interventions were applied with the ARMS population to establish if they improve sleep, improve symptoms/functioning and decrease transition to psychosis.
4.2 | Limitations

The findings about specific sleep issues being linked to increasing likelihood of experiencing six or more APS (suggestive of an ARMS) are preliminary and should be replicated in future research. Additionally, the findings should be interpreted with caution considering the following limitations. There may be concerns regarding self-selection in MTurk users. For example, in the current study, the mean total score of 7.52 for the PSQI in this sample was above the cut-off score of 6, which differentiates good and poor sleepers. It is possible that a higher proportion of MTurk users who view their sleep as poor opted to participate in this study rather than another non-sleep related study on MTurk's list. It is also possible that a higher proportion of MTurk users who experience APS opted to complete this HIT, rather than a task not related to APS. If this is the case, it may partially account for the percentage of the present sample endorsing 6 or more APS being significantly higher than previous studies. However, previous studies using crowd-sourcing such as MTurk found the data to be as reliable as data from convenience sampling, meeting the standards expected in published research, with the caveat that there may be a trend towards fewer black and Hispanic participants in university student samples, as well as having higher educational attainment than non-student samples in the United States. (Berinsky, Huber, & Lenz, 2012; Buhrmester, Kwang, & Gosling, 2011). In the present sample, 11.3% were black or Hispanic, and more than two-thirds were educated to at least degree level, whereas black and Hispanic people constitute 30.2% of the US population and only a third of the total population of the United States are educated to degree level according to 2018 census data. A further potential limitation was the use of a self-report measure of poor sleep quality. And, although previous studies have shown self-report measures to be reliable when polysomnography is also used for comparison (e.g., Reeve, Sheaves, & Freeman, 2019), it should be remembered that perception of sleep (self-report) and actual sleep (objective measure) are two different constructs. Therefore, future studies should use both measures, which may help determine the relative importance in subjective sleep and objective sleep in conferring increased risk of APS.

4.3 | Future research

Although the regression models show sleep disturbance predicting APS and related distress, the current study used a cross-sectional design; therefore, future research should consider longitudinal designs to confirm the temporal relationship between poor sleep quality and APS, and future transition to psychosis with ARMS populations. Further, as noted above, future research investigating the possible impact of sleep disturbance on cognitive processes (e.g., social cognition, jumping to conclusion bias) may demonstrate possible mechanisms through which poor sleep predicts APS. In addition to investigating variables that may mediate the relationship between sleep disturbance and APS, a valuable area of research would be to investigate if sleep interventions with ARMS populations improve symptoms/functioning and reduce transition to psychosis.

4.4 | Conclusion

The present study found a relationship between poor sleep and APS (and associated distress) after controlling for other variables known to predict ARMS status. Further research is required to establish the significance of poor sleep in predicting APS and to investigate potential mechanisms involved. It is recommended that individuals with sleep problems be treated using evidence-based treatments.

AUTHORS CONTRIBUTIONS

Dr Stephen Clarke, Western Health & Social Care Trust, Derry, Northern Ireland. Contribution: Literature search, tables, data analysis, data interpretation, drafting manuscript and critically revising the work for important intellectual content and final approval of the version to be published. Dr Donncha Hanna, Centre for Evidence and Social Innovation, Queen's University Belfast, Northern Ireland. Contribution: Substantial contribution to the conception or design of the work and critically revising the work for important intellectual content and final approval of the version to be published. Dr Sarah Davidson, Belfast Health & Social Care Trust, Belfast, Northern Ireland. Contribution: Substantial contribution to the conception or design of the work. Dr Ciarán Shannon, Holywell Hospital, Northern Health & Social Care Trust, Antrim, Northern Ireland. Contribution: Substantial contribution to the conception or design of the work and critically revising the work for important intellectual content. Dr Ciara Mulhall, School of Medicine, Dentistry and Biomedical Sciences, Queen's University Belfast, Northern Ireland. Contribution: Substantial contribution to the conception or design of the work and critically revising the work for important intellectual content.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, [D.H.], upon reasonable request.

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REFERENCES

Andorko, N. D., Mittal, V., Thompson, E., Denenny, D., Epstein, G., Demro, C., … Schiffman, J. (2017). The association between sleep dysfunction and psychosis-like experiences among college students. *Psychiatry Research*, 248, 6–12. https://doi.org/10.1016/j.psychres.2016.12.009
Anglin, D. M., Lui, F., Espinosa, A., Tikhonov, A., & Ellman, L. (2018). Ethnic identity, racial discrimination and attenuated psychotic symptoms in an urban population of emerging adults. *Early Intervention in Psychiatry*, 12(3), 380–390. https://doi.org/10.1111/epi.12314
Bentall, R., Claridge, G., & Slade, P. (1989). The multidimensional nature of schizotypal traits - a factor analytic study with normal subjects. *British Journal of Clinical Psychology*, 28, 363–375
Berinsky, A. J., Huber, G. A., & Lenz, G. S. (2012). Evaluating online labor markets for experimental research: Amazon.com’s mechanical turk. *Political Analysis*, 20(3), 351–368. https://doi.org/10.1093/pan/mpr057
Buhrmester, M., Kwang, T., & Gosling, S. D. (2011). Amazon's mechanical turk: A new source of inexpensive, yet high-quality, data? Perspectives
