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Research paper

Identifying trajectories of change in sleep disturbance during psychological treatment for depression

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ABSTRACT

Background: Sleep disturbance may impact response to psychological treatment for depression. Understanding how sleep disturbance changes during the course of psychological treatment, and identifying the risk factors for sleep disturbance response may inform clinical decision-making.
Method: This analysis included 18,915 patients receiving high-intensity psychological therapy for depression from one of eight London-based Improving Access to Psychological Therapies (IAPT) services between 2011 and 2020. Distinct trajectories of change in sleep disturbance were identified using growth mixture modelling. The study also investigated associations between identified trajectory classes, pre-treatment patient characteristics, and eventual treatment outcomes from combined PHQ-9 and GAD-7 metrics used by the services.
Results: Six distinct trajectories of sleep disturbance were identified: two demonstrated improvement, while one showed initial deterioration and the other three groups displayed only limited change in sleep disturbance, each with varying baseline sleep disturbance. Associations with trajectory class membership were found based on: gender, ethnicity, employment status, psychotropic medication use, long-term health condition status, severity of depressive symptoms, and functional impairment. Groups that showed improvement in sleep had the best eventual outcomes from depression treatment, followed by groups that consistently slept well.
Limitation: Single item on sleep disturbance used, no data on treatment adherence.
Conclusions: These findings reveal heterogeneity in the course of sleep disturbance during psychological treatment for depression. Closer monitoring of changes in sleep disturbance during treatment might inform treatment planning. This includes decisions about when to incorporate sleep management interventions, and whether to change or augment therapy with interventions to reduce sleep disturbance.

1. Introduction

Sleep disturbances (such as insomnia and hypersomnia) are reported by up to 92 % of depressed patients (Geoffroy et al., 2018; Stewart et al., 2006). Insomnia is reported by far more patients (approximately 85 %) than hypersomnia (approximately 46 %), although approximately three-in-ten patients report both types of symptom (Geoffroy et al., 2018). There is evidence to suggest a bilateral relationship between sleep disturbance and depression, where depression increases the risk of sleep disturbance and sleep disturbance leads to increased risk of depression (Fang et al., 2019; Li et al., 2016; Saunders et al., 2023).

Sleep disturbance also plays an important role in the treatment prognosis for adults with depression and in symptom change during psychological therapy (Buckman et al., 2021a; O'Driscoll et al., 2022). Meta-analyses indicate that sleep management interventions have a moderate effect on reducing depressive symptoms in the general

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population, and a large effect on patients with mental health problems (not just among those with depression) (Gee et al., 2019). Improvement in sleep disturbance symptoms also appears to be associated with improvement in depressive symptoms during psychological therapy for depression (Henry et al., 2021). However, in routine psychological therapy settings sleep management strategies are not used during the treatment of depression as regularly as the prevalence of sleep disturbance for these patients would suggest is needed. It is not surprising then that insomnia is one of the most frequent residual symptoms after depression treatment (Carney et al., 2007; Karp et al., 2004; Pigeon et al., 2009; Reynolds et al., 2020), and is associated with a greater risk of depressive relapse following treatment (Buckman et al., 2018; Saunders et al., 2021). It is also argued that untreated sleep disturbance may be preventing remission (Irwin et al., 2022). Very few studies have investigated this, however in a sample of older adults with Major Depressive Disorder (MDD), those with sleep disturbance were less likely to achieve remission at 6-and 12-months if they presented with persistent insomnia at baseline (Pigeon et al., 2008). Sleep disturbance was also found to play an important role maintaining depression and was independently associated with prognosis six-to-eight months after starting treatment for depression. However, less has been reported on the course of sleep disturbance during treatments for depression. Investigating this might elucidate means of identifying those at particular risk of poor outcomes and those that might particularly benefit from interventions to target sleep disturbance.

One investigation of change in sleep disturbance was conducted with nearly 3000 patients in a psychiatric inpatient setting, identifying four distinct trajectories of change in sleep disturbance (Hartwig et al., 2019). The findings suggested that individuals with comorbid MDD and generalized anxiety disorder (GAD) tended to have higher sleep disturbance levels, and their sleep disturbances were less likely to respond to psychiatric treatment. However, how sleep disturbance changes during treatment delivered in routine outpatient or community settings, where most psychological treatments are delivered (NHS Digital, 2021), is still unknown.

The aims of the current study are to (1) identify patient subgroups with distinct trajectories of change in sleep disturbance during routine psychological treatment for depression, (2) determine whether these trajectories are associated with differential treatment outcomes and (3) explore baseline characteristics associated with following distinct trajectories of change in sleep disturbance.

2. Method

2.1. Service and participants

Data were analysed from eight Improving Access to Psychological Therapies (IAPT, now known as NHS Talking Therapies for anxiety and depression) services that were part of the North and Central East London IAPT Service Improvement and Research Network (NCEL IAPT SIRN) (Buckman et al., 2021; Saunders et al., 2020). These National Health Service (NHS) primary care and community-based mental health teams provide evidence-based psychological treatment for depression and anxiety disorders, with over 1.6 million referrals received by IAPT services nationally each year (NHS Digital, 2021). IAPT services deliver both low-intensity (such as guided self-help, and computerised CBT) and high-intensity psychological interventions (such as individual CBT or counselling for depression) using a stepped care model, in line with national guidelines (see (Clark, 2018) for more details). IAPT services identify a "problem descriptor" as part of the initial assessment process, this represents the agreed focus of treatment between the patient and IAPT clinician, and is thus used to match the clinical problem to specific treatment protocols (IAPT, 2021). For the current study, patients were included if they were referred between 2011 and 2020, treated for depression (identified by their problem descriptor) with high-intensity psychological therapy, attended a minimum of three treatment sessions, and were recorded to have finished their treatment episode. Individuals with a problem descriptor of "Insomnia" or an alternative sleep disorder were not included in this study, as when they are treated in IAPT services it is predominantly at low intensity (and therefore will not receive high intensity interventions).

2.2. Measures

2.2.1. Depression & sleep disturbance

Self-reported depressive symptoms are assessed at every patient contact with the services using the nine-item Patient Health Questionnaire (PHQ–9; Kroenke et al., 2001) which is widely accepted for its validity and reliability (Löwe et al., 2004). Each question on the PHQ-9 has four Likert-type response options ranging from 0 "not at all" to 3 "nearly every day". Scores from each question are combined into a total score of up to 27, and a total score of ≥10 is used as the clinical cut-off for 'caseness' by the services. Item three of the PHQ-9 ("trouble falling or staying asleep, or sleeping too much") was used as the measure of sleep disturbance frequency, where scores from 0 to 3 were reported as "none", "occasional", "frequent", and "near-daily" sleep disturbance.

2.2.2. Baseline characteristic

Additional information is routinely collected within IAPT services at initial assessment with patients, and clinical measures such as symptom severity and functional impairment data are collected at each session (see Table 1).

2.2.3. Clinical outcomes

While we used item 3 of the PHQ-9 to model sessional change in sleep disturbance (see analysis detail below), only symptom severity scores at the last available session were used to calculate clinical outcomes; reliable recovery, reliable improvement, reliable deterioration, and attrition, as defined below.

- **Reliable Improvement**: reporting a reduction in symptom scores above the error of measurement for either the PHQ-9 (≥6) or GAD-7 (≥4), or both, without changes on either measure meeting criteria for reliable deterioration (see below).
- **Reliable deterioration**: a reliable increase above the error of measurement in symptoms on either the PHQ-9 or GAD-7.
- **Reliable recovery**: moving from scoring above the clinical cut-off before treatment on either the PHQ-9 (≥10) or the GAD-7 (≥8), to below clinical cut-off for both depression and anxiety at the last appointment, as well as reporting a reduction in symptom scores above the error of measurement for either measure (i.e.'reliable improvement').
- **Attrition**: whether or not an individual is reported to have dropped out during their episode of care after receiving three or more treatment sessions. This is a subjective judgement made by the clinician to denote the reason the episode of care finished.

2.3. Trajectory modelling

Growth Mixture Modelling (GMM) was used to identify patient subgroups for whom trajectories of sleep disturbance change differ. Mathematically, GMM is an application of finite mixture models, which assumes the presence of distinct latent subgroups or classes behind the data (McLachlan et al., 2019; van Nest et al., 2020). These subgroup classifications reflect the heterogeneity in a population.

We determined the optimum number of classes using established guidelines for mixture modelling and precedents (Nylund et al., 2007; Saunders et al., 2019; Skelton et al., 2022; van Nest et al., 2020). We utilized the Vuong-Lo-Mendell-Rubin test (VLMR; Lo et al., 2001), the Bayesian Information Criterion (BIC), and entropy as model selection criteria. VLMR compares a K-class to a K-1 class model (Lo et al., 2001), with a p-value < 0.05 signifying better fit for the k model (McNeish and

Table 1
Routinely collected data and measures.

Baseline Characteristic	Questionnaire	Additional Information/ thresholds
Anxiety symptoms	The Generalized Anxiety Disorder Scale 7-item version (GAD-7; Spitzer et al., 2006)	Scores of 8 or above indicate clinical caseness on the GAD-7, while a change of 4 or more indicates reliable change on the measure.
Phobic anxiety	IAPT Phobia scales (IAPT, 2021)	The IAPT phobia scales are three questions which assess the extent that a person avoids situations related to agoraphobia, social phobia and specific phobia.
Functional and Social impairment	The Work and Social Adjustment Scale (WSAS; Mundt et al., 2002)	Measures of functional and social impairment were measured using items 2, 3, 4 and 5 ('home management', 'social activities', 'private leisure activities' and 'close relationships', respectively) of the WSAS. Item 1 ('Ability to work') was not considered in the current analysis as it is routinely scored "N/A" for those not in employment.
Demographics	Age at referral, gender, ethnicity, The Index of Multiple Deprivation (IMD; Ministry of Housing Communities and Local Government, 2019)	Ethnicity uses the UK census codes ('White', 'Mixed', 'Asian', 'Black', and 'other'). IMD is an official measure reflecting a wide range of an individual's living conditions including income, employment, barriers to services, and crime etc. All demographic data were self-reported.
Long-term health conditions	'present' or 'not present'	Long-term conditions recorded whether a patient had conditions such as arthritis, diabetes, hypertension, cardiac problems, and pulmonary diseases (NHS Digital, 2021).
Medication	'prescribed' or 'not prescribed'	Psychotropic medication use was reported at assessment.
Employment status	'employed' or 'unemployed'	All participants are asked to report their employment status at assessment.
Time to assessment		Weeks between referral and first assessment
Time to treatment		Weeks between assessment and the first treatment session

(Adapted from Buckman et al., 2021b.)

Harring, 2016). Lower BIC indicates a better model fit. Unlike Akaike Information Criterion (AIC), BIC support parsimonious models without overestimating components, beneficial for estimating latent sleep trajectories (Henson et al., 2007; van Nest et al., 2020). Higher entropy values indicate better classification accuracy of the model.

2.4. Plan of analysis

First, GMM were performed on the PHQ-9 sleep-item scores to model the trajectory classes of sleep disturbance. All models were fitted with quadratic curves as previous research demonstrated that quadratic factors best represent treatment response data in similar settings (Fiorini et al., 2022; Hartwig et al., 2019; Saunders et al., 2019). GMM were fitted using sleep disturbance data for the first 12 sessions only, in line with previous research using data from these types of services (Saunders et al., 2019). In this dataset, the mean number of sessions was 9.62 (SD = 4.73) including the baseline assessment. As there were no prior hypotheses on the number of classes, the GMM was first fitted with a two-class model. After assessing the fit statistics, the number of classes was increased iteratively until either the VLMR became non-significant or any of the BIC values increased compared to the previous values, as is standard for GMM methods (Geiser, 2013; Musliner et al., 2016). Following the convention of using GMM, the smallest class assignment had to contain at least 5 % of the sample for it to have clinical utility (Gueorguieva et al., 2011; Saunders et al., 2019; Spinhoven et al., 2016).

Following the identification of the optimum GMM solution, posterior analysis was conducted in the latent classes generated by GMM. In the first set of analyses, logistic regression models were fitted with trajectory class as the independent variable and the four outcome variables (each in separate models: reliable improvement, reliable recovery, reliable deterioration and dropout) as dependent variables. In the second phase, multinomial logistic regression was used to investigate whether patient demographic (age, gender, ethnicity, employment status, and Index of Multiple Deprivation) and other clinical characteristics (Work and Social Adjustment Scale [WSAS], Phobia scores, prescribed medication, long-term condition, baseline PHQ-9 and GAD-7 scores), were risk factors for sleep trajectory membership. In all regression models, we considered risk factors statistically significant when Wald-test p-values were <0.05, given the exploratory nature of these analyses.

2.5. Software, packages and missing data

GMM was performed using Mplus version 8.3 (Muthén and Muthén, 2017). For GMM analyses, missing PHQ-9 sleep item data were handled using Full Information Maximum-Likelihood through the Expectation Maximisation (EM) algorithm (Dempster et al., 1977) as standard in Mplus. Multinomial and logistic regression models were fitted in Stata version 17 (StataCorp, 2021), imputing missing data on potential baseline variables associated with sleep trajectory classes using multiple imputations with chained equations (MICE) in Stata. All imputation models used the complete data on baseline PHQ-9 sleep scores, baseline PHQ-9 total scores, medication prescription status, long-term condition, clinical outcome measures (reliable recovery, reliable improvement, deterioration, dropout), along with demographic variables (age, gender, ethnicity, unemployment, WSAS, IMD). Imputation models use linear regression for continuous variables, logistic regression for dichotomous variables and ordered logistic and nominal regression models for ordered and un-ordered categorical variables respectively, with an augmentation procedure to avoid bias due to perfect prediction (White et al., 2010). One hundred imputed datasets were estimated and used in multinomial logistic regression models of baseline variables and clinical outcomes against the sleep trajectory classes.

3. Results

3.1. Descriptive statistics

The data exclusion flowchart is presented in Supplementary Fig. S1. From a total of 84,817 patients potentially eligible for the study by commencing treatment for depression, 42,214 (49.8 %) did not meet inclusion criteria as they ended their episode of care with fewer than the minimum of three time-points with complete data required to perform GMM. A further 23,016 (27.1 %) did not meet inclusion criteria as they received two or more sessions of a low intensity intervention. Finally, 627 (0.74 %) did not meet inclusion criteria as they were still in treatment and therefore their treatment outcomes could not be determined. This study included 18,915 patients who were treated for depression by the IAPT services. See Table 2 for the descriptive statistics of the sample.

3.2. Trajectories of sleep disturbance change

3.2.1. Model fit statistics

GMM was performed on the PHQ-9 sleep item with models including two to seven classes computed. Model fit statistics are presented in

Table 2
Descriptive statistics of the sample.

Variable name	Category	N (%)	Mean (S.D.)	Missing N (%)
Gender				62 (0.33 %)
	Female	12,955 (68.72 %)		
	Male	5898 (31.28 %)		
Ethnicity				640 (3.38 %)
	Asian	2753 (15.06 %)		
	Black	2274 (12.44 %)		
	Mixed	1200 (6.57 %)		
	Other	717 (3.92 %)		
	White	11,331 (62.00 %)		
Employment status				270 (1.43 %)
	Employed	13,216 (70.88 %)		
	Unemployed	5429 (29.12 %)		
IMD Decile			3.93 (2.20)	298 (1.58 %)
	1	1838 (9.87 %)		
	2	4110 (22.08 %)		
	3	3710 (19.93 %)		
	4	2584 (13.88 %)		
	5	1843 (9.90 %)		
	6	1742 (9.36 %)		
	7	1098 (5.90 %)		
	8	1064 (5.72 %)		
	9	447 (2.40 %)		
	10	181 (0.97 %)		
Prescribed medication				1519 (8.03 %)
	No	10,206 (58.67 %)		
	Yes	7190 (41.33 %)		
Long-term condition				4041 (21.36 %)
	No	9921 (66.70 %)		
	Yes	4953 (33.30 %)		
Service				0 (0.00 %)
	Trust 1	8340 (44.09 %)		
	Trust 2	1625 (8.59 %)		
	Trust 3	4180 (22.10 %)		
	Trust 4	4770 (25.22 %)		
Age at referral			38.90 (13.36)	0 (0.00 %)
Baseline PHQ-9 Score			16.60 (5.77)	21 (0.11 %)
Baseline GAD-7 Score			13.87 (5.00)	31 (0.16 %)
Baseline WSAS Item 2			4.01 (2.44)	441 (2.33 %)
Baseline WSAS Item 3			4.68 (2.47)	442 (2.34 %)
Baseline WSAS Item 4			4.04 (2.58)	443 (2.34 %)
Baseline WSAS Item 5			4.49 (2.45)	447 (2.36 %)
Baseline Agoraphobia Score			2.77 (2.76)	413 (2.18 %)
Baseline Social Phobia Score			3.52 (2.62)	409 (2.16 %)
Baseline Specific Phobia Score			2.38 (2.77)	416 (2.20 %)
Weeks to Assessment			4.71 (8.04)	3 (0.02 %)
Weeks to Treatment			12.57 (10.45)	818 (4.32 %)

Notes: IMD = Index of Multiple Deprivation, PHQ-9 = Patient Health Questionnaire 9-item, GAD-7 = The Generalized Anxiety Disorder Scale 7-item version, WSAS = The Work and Social Adjustment Scale. Service = Local Healthcare Trust of the service.

Supplementary Table S1. Considering the VLMR, BIC, and entropy statistics the 6-class model was selected as the optimum fit for the data. Growth parameter statistics for the identified trajectories are presented in Supplementary Table S2.

3.2.2. Class description

The identified six trajectory classes are presented in Fig. 1, sorted by baseline average sleep disturbance from the most frequent to the least frequent (represented by initial sleep disturbance frequency score). The following descriptions were given to each trajectory:

- ***Rapid Reduction - Initial Frequent*** — Near-daily sleep disturbance pre-treatment, becoming occasional soon after treatment begins, increases in frequency in late treatment. N = 1890 (10.0 %)
- ***Gradual Reduction - Initial Frequent*** — Near-daily sleep disturbance pre-treatment, frequent mid-treatment, occasional or none by late treatment. N = 2102 (11.1 %)
- ***Persistent Frequent Disturbance*** — Frequent sleep disturbance for the duration of treatment. N = 7359 (38.9 %)
- ***Persistent Occasional Disturbance*** — Occasional sleep disturbance throughout treatment. N = 3777 (20.0 %)
- ***Early Deterioration - Initial Infrequent*** — Occasional sleep disturbance pre-treatment, near-daily or frequent mid-treatment, becoming frequent later in treatment. N = 1325 (7.0 %)
- ***Consistent Infrequent Disturbance*** — None or occasional sleep disturbance pre-treatment, minimal change throughout the treatment. N = 2462 (13.0 %)

3.3. Clinical outcome differences

Clinical outcomes and logistic regression comparison of each group to the *Persistent Occasional Disturbance group* are shown in Table 3. The *Gradual Reduction - Initial Frequent* (75.6 %) and *Rapid Reduction - Initial Frequent* (72.9 %) groups had the highest rates of reliable recovery, followed by the *Consistent Infrequent Disturbance* (71.0 %) and *Persistent Occasional Disturbance* (64.6 %) groups. The *Early Deterioration - Initial Infrequent* (31.7 %) and *Persistent Frequent Disturbance* (20.1 %) groups had the lowest reliable recovery rate. Groups that had improvement in sleep (both *Rapid Reduction - Initial Frequent* and *Gradual Reduction - Initial Frequent*) were three times more likely to recover than those in the *Persistent Frequent Disturbance group*. The *Persistent Frequent Disturbance*

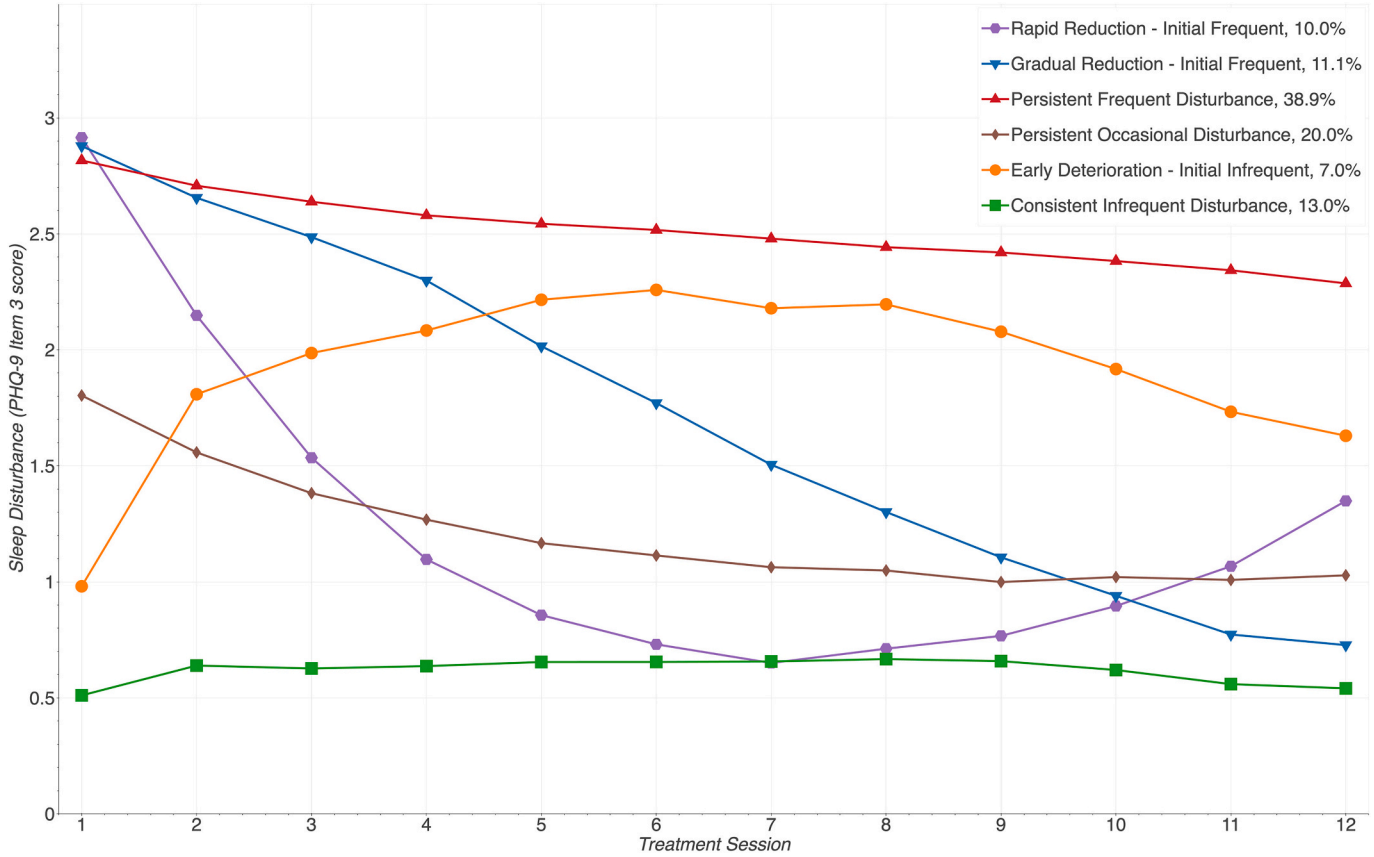

Fig. 1. Trajectories of sleep disturbance during psychological treatment identified.

Table 3
Clinical outcomes by trajectory class and odds ratios (with *Persistent Occasional Disturbance* as the reference category).

Clinical outcome	Reliable recovery				Reliable improvement			
	n (%)	Odds ratio	95 % conf. interval	p-value	n (%)	Odds ratio	95 % conf. interval	p-value
Persistent Occasional Disturbance	2248 (64.6 %)	1			2943 (78.0 %)	1		
Early Deterioration - Initial Infrequent	383 (31.7 %)	0.25	0.22–0.29	<0.001	675 (51.0 %)	0.29	0.26–0.34	<0.001
Consistent Infrequent Disturbance	1288 (71.0 %)	1.34	1.18–1.51	<0.001	1651 (67.1 %)	0.58	0.51–0.65	<0.001
Persistent Frequent Disturbance	1467 (20.1 %)	0.14	0.13–0.15	<0.001	4104 (55.8 %)	0.36	0.33–0.39	<0.001
Rapid Reduction - Initial Frequent	1335 (72.9 %)	1.47	1.30–1.67	<0.001	1728 (91.5 %)	3.05	2.55–3.65	<0.001
Gradual Reduction - Initial Frequent	1571 (75.6 %)	1.70	1.50–1.92	<0.001	1965 (93.5 %)	4.05	3.35–4.90	<0.001

Clinical outcome	Deterioration				Dropout			
	n (%)	Odds ratio	95 % conf. interval	p-value	n (%)	Odds ratio	95 % conf. interval	p-value
Persistent Occasional Disturbance	160 (4.2 %)	1			673 (18.8 %)	1		
Early Deterioration - Initial Infrequent	263 (19.9 %)	5.61	4.55–6.90	<0.001	297 (24.5 %)	1.40	1.20–1.64	<0.001
Consistent Infrequent Disturbance	126 (5.1 %)	1.22	0.96–1.55	0.104	386 (16.6 %)	0.86	0.75–0.98	0.029
Persistent Frequent Disturbance	780 (10.6 %)	2.68	2.25–3.19	<0.001	2155 (33.1 %)	2.14	1.94–2.36	<0.001
Rapid Reduction - Initial Frequent	39 (2.1 %)	0.48	0.33–0.68	<0.001	399 (22.2 %)	1.23	1.07–1.42	0.003
Gradual Reduction - Initial Frequent	33 (1.6 %)	0.36	0.25–0.53	<0.001	223 (11.0 %)	0.53	0.45–0.63	<0.001

(33.1 %) and *Early Deterioration - Initial Infrequent* (24.5 %) groups had the highest rates of treatment dropout, followed by the *Rapid Reduction - Initial Frequent* (22.2 %) and *Persistent Occasional Disturbance* (18.8 %). The *Consistent Infrequent Disturbance* (16.6 %) and *Gradual Reduction - Initial Frequent* (11.0 %) groups had the lowest dropout rates.

3.4. Association between baseline characteristics and trajectory class

Following this, multinomial regression models were constructed to examine the association between characteristics of patients at baseline and trajectory class followed, with the *Persistent Occasional Disturbance* group used as the reference category in comparisons. Females had higher odds of being in the *Persistent Frequent Disturbance* group and lower odds of being in the *Consistent Infrequent Disturbance* group (see Table 4). Patients identifying as from Asian ethnic backgrounds had higher odds of being in the *Early Deterioration - Initial Infrequent* group. Patients from Black ethnic backgrounds had higher odds of being in either the *Rapid Reduction - Initial Frequent* or *Gradual Reduction - Initial Frequent*. Unemployment was associated with increased odds of belonging to the *Early Deterioration - Initial Infrequent* and the *Persistent*

Table 4
Baseline variables by trajectory class and odds ratios (with *Persistent Occasional Disturbance* as the reference category).

Baseline characteristic	*Consistent Infrequent Disturbance*			*Early Deterioration - Initial Infrequent*			*Rapid Reduction - Initial Frequent*		
	Odds ratio	95 % conf. interval	p-value	Odds ratio	95 % conf. interval	p-value	Odds ratio	95 % conf. interval	p-value
Age at referral	1.00	0.99–1.00	0.762	0.99	0.99–1.00	0.028	1.00	1.00–1.01	0.068
Gender									
Female	0.82	0.73–0.92	0.001	0.99	0.86–1.14	0.873	1.00	0.88–1.14	0.953
Ethnicity									
Asian	1.04	0.87–1.24	0.671	1.27	1.04–1.54	0.019	0.94	0.78–1.13	0.522
Black	1.01	0.83–1.23	0.916	1.04	0.84–1.28	0.745	1.45	1.20–1.76	<0.001
Mixed	1.09	0.86–1.38	0.468	0.91	0.69–1.20	0.509	1.04	0.82–1.33	0.735
Other	0.78	0.56–1.10	0.156	1.15	0.82–1.61	0.424	0.90	0.65–1.26	0.556
IMD Decile	1.04	1.01–1.07	0.011	0.97	0.94–1.00	0.060	0.99	0.96–1.02	0.342
Unemployment	0.87	0.74–1.02	0.076	1.50	1.28–1.75	<0.001	1.02	0.88–1.18	0.807
Prescribed medication	0.85	0.74–0.97	0.014	1.15	0.99–1.32	0.064	1.00	0.88–1.14	0.980
Long-term Condition	1.04	0.90–1.21	0.553	1.16	0.99–1.37	0.069	1.03	0.88–1.19	0.746
Baseline PHQ-9 Score	0.83	0.82–0.85	<0.001	0.93	0.91–0.94	<0.001	1.19	1.17–1.22	<0.001
Baseline GAD-7 Score	1.00	0.99–1.02	0.584	1.03	1.01–1.04	0.005	0.98	0.97–1.00	0.027
Baseline WSAS Item 2	0.96	0.93–0.99	0.015	1.02	0.99–1.06	0.195	0.98	0.95–1.01	0.177
Baseline WSAS Item 3	1.06	1.03–1.10	0.001	1.09	1.05–1.14	<0.001	1.00	0.97–1.04	0.930
Baseline WSAS Item 4	0.98	0.95–1.01	0.184	1.02	0.98–1.05	0.334	0.99	0.96–1.03	0.737
Baseline WSAS Item 5	1.01	0.98–1.04	0.548	1.02	0.99–1.05	0.238	0.97	0.95–1.00	0.084
Baseline Agoraphobia Score	0.98	0.95–1.01	0.126	1.02	0.99–1.05	0.241	1.01	0.98–1.04	0.457
Baseline Social Phobia Score	1.01	0.98–1.04	0.529	1.04	1.01–1.08	0.012	0.97	0.94–1.00	0.039
Baseline Specific Phobia Score	0.99	0.96–1.02	0.382	1.02	0.99–1.05	0.182	0.98	0.95–1.01	0.132
Service									
Trust 2	0.90	0.73–1.09	0.283	0.92	0.72–1.17	0.493	0.79	0.63–0.99	0.037
Trust 3	0.99	0.85–1.16	0.906	1.12	0.95–1.34	0.184	0.90	0.77–1.07	0.228
Trust 4	0.86	0.74–1.00	0.054	0.90	0.75–1.08	0.244	1.14	0.97–1.33	0.111
Weeks to Assessment	1.00	1.00–1.00	0.874	1.00	1.00–1.00	0.512	1.00	1.00–1.00	0.090
Weeks to Treatment	1.00	1.00–1.00	0.608	1.00	1.00–1.00	0.257	1.00	1.00–1.00	0.386

Baseline characteristic	*Gradual Reduction - Initial Frequent*			*Persistent Frequent Disturbance*		
	Odds ratio	95 % conf. interval	p-value	Odds ratio	95 % conf. interval	p-value
Age at referral	1.00	0.99–1.00	0.211	1.00	0.99–1.00	0.396
Gender						
Female	1.14	1.00–1.30	0.050	1.19	1.07–1.32	0.001
Ethnicity						
Asian	0.90	0.74–1.08	0.260	0.95	0.82–1.10	0.516
Black	1.31	1.08–1.58	0.006	1.16	0.99–1.35	0.062
Mixed	1.01	0.79–1.30	0.917	1.01	0.83–1.23	0.907
Other	1.01	0.73–1.39	0.951	1.01	0.79–1.29	0.950
IMD Decile	0.98	0.95–1.01	0.271	0.97	0.94–0.99	0.005
Unemployment	1.08	0.93–1.25	0.325	1.65	1.47–1.85	<0.001
Prescribed medication	1.10	0.96–1.25	0.174	1.23	1.11–1.36	<0.001
Long-term Condition	1.17	1.01–1.36	0.040	1.33	1.19–1.50	<0.001
Baseline PHQ-9 Score	1.23	1.21–1.25	<0.001	1.24	1.22–1.26	<0.001
Baseline GAD-7 Score	0.99	0.98–1.01	0.403	1.02	1.00–1.03	0.023
Baseline WSAS Item 2	1.02	0.99–1.05	0.287	1.03	1.00–1.05	0.027
Baseline WSAS Item 3	1.03	1.00–1.07	0.058	1.06	1.03–1.09	<0.001
Baseline WSAS Item 4	0.99	0.96–1.02	0.617	1.01	0.99–1.04	0.342
Baseline WSAS Item 5	0.98	0.95–1.01	0.171	0.99	0.97–1.01	0.363
Baseline Agoraphobia Score	1.01	0.98–1.04	0.555	1.02	1.00–1.05	0.041
Baseline Social Phobia Score	0.99	0.96–1.02	0.467	0.99	0.97–1.01	0.328
Baseline Specific Phobia Score	1.01	0.99–1.04	0.325	1.02	1.00–1.04	0.072
Service						
Trust 2	0.92	0.74–1.15	0.480	1.07	0.90–1.27	0.443
Trust 3	0.92	0.78–1.09	0.327	1.18	1.04–1.34	0.012
Trust 4	1.01	0.86–1.19	0.899	1.11	0.97–1.26	0.119
Weeks to Assessment	1.00	1.00–1.00	0.334	1.00	1.00–1.00	0.004
Weeks to Treatment	1.00	1.00–1.00	0.414	1.00	1.00–1.00	0.059

Notes: IMD = Index of Multiple Deprivation, PHQ-9 = Patient Health Questionnaire 9-item version, GAD-7 = The Generalized Anxiety Disorder Scale 7-item version, WSAS = The Work and Social Adjustment Scale. Services = Local Healthcare Trust of the service.

Frequent Disturbance. People who were prescribed psychotropic medication were more likely to be in the *Persistent Frequent Disturbance* and less likely to be in the *Consistent Infrequent Disturbance*. Those with long-term health conditions were more likely to be in the *Persistent Frequent Disturbance*. Milder depressive symptoms pre-treatment were associated with being in the *Consistent Infrequent Disturbance* and the *Early Deterioration - Initial Infrequent*. Comorbid generalized anxiety disorder symptoms were not associated with sleep disturbance trajectory class membership. A higher rating of WSAS item 3 (indicating impairment in 'social activities') was associated with higher odds of being in either the *Early Deterioration - Initial Infrequent* or *Persistent Frequent Disturbance*, as was being younger at referral. Higher GAD-7 scores increased the likelihood of following the *Early Deterioration* and the *Persistent Frequent Disturbance* groups, and reduced the likelihood of following the *Rapid Reduction* group. Higher specific phobia symptoms increased the likelihood of following the *Early Deterioration* group, while higher levels of

agoraphobia were associated with the *Persistent Frequent Disturbance* group.

3.5. Sleep non-improvement

Three groups (*Persistent Frequent Disturbance*, *Rapid Reduction - Initial Frequent*, and *Gradual Reduction - Initial Frequent*, accounting for 60 % of patients) had daily baseline sleep disturbance, but their trajectories diverged soon after the treatment started. Logistic regression results between the three groups with the *Persistent Frequent Disturbance* group as the reference category are shown in Table 5. Similarly, reporting being female, being unemployed, taking psychotropic medication, having a long-term condition, having higher baseline depression, and having higher WSAS item 2 ('home management') and item 3 ('social activities') scores were associated with non-improvement of sleep disturbance.

4. Discussion

4.1. Overview

This study identified six distinct trajectories of the course of sleep disturbance symptoms during the initial twelve sessions of psychological treatment for depression. These included three trajectories characterised by sleep disturbance change: a *Rapid Reduction - Initial Frequent*, and *Gradual Reduction - Initial Frequent*, and an *Early Deterioration - Initial Infrequent*, accounting for 10.0 %, 11.1 %, and 7.0 % of patients, respectively. The other three groups had relatively stable sleep disturbance during treatment but were differentiated by the level of pre-treatment severity: *Persistent Frequent Disturbance*, *Persistent Occasional Disturbance*, and *Consistent Infrequent Disturbance* accounting for 38.9 %, 20.0 %, and 13.0 % of patients respectively. The *Gradual Reduction - Initial Frequent* and *Rapid Reduction - Initial Frequent* reported the best eventual treatment outcomes, followed by the *Consistent Infrequent Disturbance* and the *Persistent Occasional Disturbance*. The *Early Deterioration - Initial Infrequent* and the *Persistent Frequent Disturbance* had the worst treatment outcomes. To illustrate, among the *Early Deterioration - Initial Infrequent* only 31.7 % of patients reliably recovered and 19.9 % reliably deteriorated, this compares to 75.6 % that reliably recovered and 1.6 % that reliably deteriorated in the *Gradual Reduction - Initial Frequent group*. Patients were more likely to be in the *Early Deterioration - Initial Infrequent* if they: had more daily depressive symptoms at baseline, were unemployed, had worse social functioning, and identified as being of Asian ethnicity.

Unlike in studies modelling depressive symptom trajectories by Hartwig et al. (2019), Saunders et al. (2019), or Skelton et al. (2022), an *Early Deterioration - Initial Infrequent* was found in this study. Given these previous studies modelled total depression severity only, the current findings might indicate that sleep is a particularly vulnerable symptom to deteriorating, at least early in treatment. This may be linked to a number of variables which were not available in the current dataset, such as initiating specific types of antidepressant treatments (Wichniak et al., 2017), and/or withdrawal from them (Gemma et al., 2021). Potentially other factors such as stressful life events including financial concerns, being a victim of crime or relationship endings, known to be associated with poor depression treatment prognosis (Buckman et al., 2022) may have already set individuals on such a trajectory. Therefore, a better understanding the individual processes of change needs to be elucidated, and future research that is able to help identify these individuals could further support treatment planning.

The associations of baseline variables with trajectory classes were consistent with the literature on differences in sleep disturbance by gender (Zeng et al., 2020), ethnicity (Johnson et al., 2019), unemployment (Maeda et al., 2019), and comorbid long-term health conditions (Ohayon, 2005). Being prescribed psychotropic medication was associated with membership to the *Persistent Frequent Disturbance*. It could be that this group, having more chronic sleep disturbance, was more likely to have received pharmacological treatment before treatment. Their relatively poor treatment outcomes could stem from treatment resistance, evidenced by unchanged sleep disturbance despite a combination

Table 5
Baseline characteristics by trajectory and odds ratios (with *Persistent Frequent Disturbance* as the reference category).

Baseline characteristic	*Rapid Reduction - Initial Frequent*			*Gradual Reduction - Initial Frequent*		
	Odds ratio	95 % conf. interval	p-value	Odds ratio	95 % conf. interval	p-value
Age at referral	1.01	1.00–1.01	0.014	1.00	1.00–1.00	0.956
Gender						
Female	0.87	0.78–0.98	0.023	0.96	0.86–1.07	0.446
Ethnicity						
Asian	0.97	0.82–1.14	0.674	1.00	0.86–1.17	0.988
Black	1.21	1.03–1.42	0.021	1.15	0.99–1.34	0.077
Mixed	1.06	0.85–1.32	0.627	0.95	0.77–1.17	0.625
Other	0.91	0.68–1.22	0.543	1.02	0.79–1.32	0.865
IMD Decile	1.02	1.00–1.05	0.092	1.02	0.99–1.04	0.192
Unemployment	0.58	0.51–0.66	<0.001	0.61	0.54–0.68	0.000
Prescribed medication	0.82	0.73–0.92	0.001	0.91	0.82–1.01	0.090
Long-term Condition	0.74	0.65–0.85	<0.001	0.85	0.75–0.96	0.011
Baseline PHQ-9 Score	0.97	0.96–0.99	<0.001	0.99	0.97–1.00	0.135
Baseline GAD-7 Score	0.97	0.95–0.98	<0.001	0.98	0.96–0.99	0.002
Baseline WSAS Item 2	0.96	0.93–0.99	0.004	0.98	0.96–1.01	0.222
Baseline WSAS Item 3	0.95	0.92–0.98	0.001	0.98	0.95–1.01	0.112
Baseline WSAS Item 4	0.98	0.96–1.01	0.254	0.98	0.96–1.01	0.178
Baseline WSAS Item 5	0.98	0.95–1.00	0.054	0.98	0.96–1.00	0.117
Baseline Agoraphobia Score	0.98	0.95–1.00	0.066	0.97	0.95–1.00	0.030
Baseline Social Phobia Score	0.99	0.96–1.01	0.244	1.00	0.98–1.02	0.941
Baseline Specific Phobia Score	0.96	0.93–0.98	<0.001	1.00	0.97–1.02	0.644
Services						
Trust 2	0.77	0.62–0.95	0.015	0.92	0.76–1.11	0.362
Trust 3	0.78	0.67–0.90	0.001	0.80	0.70–0.92	0.001
Trust 4	1.01	0.88–1.16	0.922	0.93	0.81–1.06	0.263
Weeks to Assessment	1.00	1.00–1.00	<0.001	1.00	1.00–1.00	<0.001
Weeks to Treatment	1.00	1.00–1.00	0.014	1.00	1.00–1.00	0.578

Notes: IMD = Index of Multiple Deprivation, PHQ-9 = Patient Health Questionnaire 9-item, GAD-7 = The Generalized Anxiety Disorder Scale 7-item version, WSAS = The Work and Social Adjustment Scale. Services = Local Healthcare Trust of the service.

of pharmacotherapy and psychological therapy. Alternatively, it could be that their pharmacological treatment was not optimized to improve their sleep disturbance, or even that it exacerbated sleep disturbance symptoms prior to starting their IAPT therapy. Further investigation into the medication's type, class, dose and duration is needed for more clarity, but unfortunately, such details weren't available in this study.

4.2. Sleep and depression

Over recent years, it has been suggested that sleep disturbance may be preventing some patients with depression from reaching remission (Franzen and Buysse, 2008; Hartwig et al., 2019; Irwin et al., 2022). Our study provides further evidence that improvement in sleep disturbances is associated with better depression outcomes. Specifically, even with highest levels of baseline sleep disturbance, *Gradual Reduction - Initial Frequent* and *Rapid Reduction - Initial Frequent* demonstrated also highest depression recovery, comparable to those starting with lower levels of sleep disturbance (*Consistent Infrequent Disturbance* and *Persistent Occasional Disturbance*). Interestingly, a significant minority achieved recovery without sleep improvement, suggesting sleep improvement is important though might not be necessary for depression remission, possibly due to improvement in other symptoms. It should be noted that sleep disturbance is a symptom of depression, and a specific item on the PHQ-9. Finding that some individual's change in sleep does not correspond to recovery might be linked to comorbidities, for e.g. trauma reprocessing, which may dis-entangle sleep from depression in certain instances. That notwithstanding, these findings may have important implications for clinical practice since for those whose sleep disturbance improved during psychological therapy, 3 in 4 achieved reliable recovery (*Rapid Reduction - Initial Frequent* and *Gradual Reduction - Initial Frequent*, accounting for 21.1 % of patients), and in contrast, 3 in 4 patients whose sleep disturbance did not improve did not achieve reliable recovery at the end of treatment (*Persistent Frequent Disturbance* and *Early Deterioration - Initial Infrequent*, accounting for 45.9 % of patients).

4.3. Limitations

This study uses a single item in PHQ-9 to capture the sleep disturbance changes. While it has been used in previous research (e.g. Hartwig et al., 2019), precision of the sleep disturbance reflected by the single item may be limited, and the sleep item does not differentiate between insomnia and hypersomnia (lack of sleep or too much sleep). More thorough measures of sleep disturbance such as the Pittsburgh Sleep Quality Index (Buysse et al., 1989), might provide more detailed information that could lead to the identification of different trajectories. Data were gathered from eight psychological therapy services for this study, and the patient sample may not be representative of those seen in other services or in other treatment settings. The inclusion criteria for the sample required that individuals had at least three sessions of treatment for the modelling approach, had finished treatment and received only high intensity therapy, meaning the findings may not generalise to all patients treated by these services. Additionally, other potentially important baseline variables were not available but may confound the effects we have found. For example, the experience of stress (Kalmbach et al., 2018), caring responsibilities for small children or dependent adults, travel or shift work (Åkerstedt and Wright, 2009), substance use, and smoking. Other important variables to consider in future work in this area are comorbid trauma and symptoms of post-traumatic stress-disorder (PTSD), as well as substance-use disorders, which are known to impact sleep (Koffel et al., 2016; Roehrs and Roth, 2015) but were not available in the current study. Given the differential impact of specific psychotropic medications on sleep (Wichniak et al., 2017) and the effect of withdrawal symptoms when discontinuing such medications, further studies should include these data from participants. While not available in the current dataset, this may have important impacts for treatment planning. We did not consider adjustment for multiple testing appropriate for the context of this study (Perneger, 1998; Rothman, 1990) and instead focused on providing all results of these exploratory analyses. Nonetheless, the interpretation of the p-values presented should be considered in this context to avoid making Type 1 errors. While beyond the scope of this study, further analysis identifying trajectories of change in sleep disturbance during other psychological treatments such as anxiety treatments may also be of value.

In this study, all patients received High Intensity psychological therapies (Clark et al., 2018). CBT for insomnia is not routinely used as a standalone high intensity treatment for depression in IAPT services (although a digital version of the treatment is available at low intensity in many services), but given the familiarity of many IAPT clinicians that deliver High Intensity treatments with these techniques, it is likely that they are used on a bespoke basis for their patients. Due to lack of data on treatment protocol adherence, we couldn't assess the effects of receiving different sleep management interventions. This limits our understanding of patient trajectory determinants and what specifically enhances treatment outcomes. Better understanding of specifics of therapeutic interventions, their timing, and reasons behind them may elucidate greater knowledge on how to improve outcomes for patients with depression and sleep disturbances.

4.4. Implications and conclusions

Having identified groups of patients that experience different forms of change in sleep disturbance symptoms and differing treatment outcomes during psychological therapy, our findings suggest potential areas for further clinical exploration.

For the *Persistent Frequent Disturbance* group, introducing sleep management techniques including sleep hygiene, stimulus control, sleep restriction, cognitive therapy, and relaxation training, as interventions used in protocols of CBT for Insomnia (National Institute for Health Care and Excellence [NICE], 2022; van Straten et al., 2018), might reduce the risk of poorer outcomes. Given that patients in this group are more often prescribed psychotropic medications, liaising with prescribing clinicians to review and, where appropriate, adjust these medication to match clinical guidelines could be beneficial (National Institute for Health Care and Excellence [NICE], 2022). Considering the specific medications being prescribed, and the potential withdrawal effects if patients are discontinuing those medications, might further inform the personalisation of psychological treatment delivery and monitoring of the impact on sleep. While our data shows this group was the least likely to reliably recover, it points to a potential benefit in researching the effects of more intensive treatment options at the outset and examining the impact of adjunctive interventions that address sleep disturbance and comorbid issues such as alcohol/substance use, or tobacco smoking (Firth et al., 2020).

For the *Early Deterioration - Initial Infrequent* or *Persistent Occasional Disturbance,* their observed sleep patterns may hint at a need for a different therapeutic approach. However, caution should be exercised given their varied clinical outcomes. While our study suggests that pre-treatment data alone might not predict trajectory classes, the importance of early sleep disturbance monitoring could be a potential area of future research. For example, there is early evidence to suggest that providing clinicians with feedback on the patients' probable symptom trajectory can lead to improved treatment outcomes (Carlier et al., 2012; Delgadillo et al., 2018; Shimokawa et al., 2010).

Regarding the *Gradual Reduction - Initial Frequent* or *Rapid Reduction - Initial Frequent* Groups, our data does not indicate a need to deviate from current practices. However, the lack of detailed therapy session data means that definitive conclusions regarding specific interventions cannot be made.

In conclusion, our study offers a foundational insight into the interplay between sleep disturbances and therapy outcomes. To transition these insights into actionable clinical recommendations, further targeted and in-depth research is imperative.

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CRediT authorship contribution statement

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Declaration of competing interest

All authors declare that there are no conflicts of interest.

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Appendix A. Supplementary data

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