Journal of Affective Disorders 412 (2026) 122052

Contents lists available at ScienceDirect

Journal of Affective Disorders

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

Research paper

Treatment outcomes across subgroups of stroke survivors receiving psychological treatment for anxiety and depression

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ARTICLE INFO

Keywords:
Depression
Anxiety
Stroke
Latent class analysis

ABSTRACT

Background: Stroke increases the risk of developing depression and anxiety. While psychological therapies are a recommended first-line treatment, outcomes vary between stroke survivors. Identifying those at risk of poorer treatment outcomes could improve treatment selection and patient outcomes. This study aimed to identify classes of stroke survivors based on stroke-related clinical characteristics and examine their psychological treatment outcomes.
Methods: NHS Talking Therapies for anxiety and depression (NHS TTad) data, linked to secondary care health records, were used to identify stroke survivors referred to TTad services across England from 2012 to 2019 (N = 6349). Latent class analysis was used to identify patient subgroups based on stroke type, time from stroke diagnosis to psychological treatment, presence of hemiplegia or paraplegia, and physical comorbidities. A distal categorical outcome approach was used to assess treatment across classes. Logistic regression models were used to examine outcomes by treatment intensity within each class.
Results: Four statistically distinct classes were identified, primarily differentiated by the type of stroke and time to access psychological treatment. Reliable recovery rates varied from 50 to 55% across classes, with deterioration rates ranging from 5 to 8%. High-intensity treatment was associated with reduced dropout rates in three classes.
Conclusion: There were limited differences in psychological treatment outcomes between classes of stroke survivors. Stroke-related variables used in this study appear insufficient on their own to meaningfully stratify stroke survivors by psychological treatment prognosis. Future research should incorporate additional patient-level data, such as measures of cognition and language, to develop more clinically informative subgrouping.

1. Introduction

Stroke survivors frequently experience common mental disorders. Post-stroke depression affects 29% of survivors (Ayerbe et al., 2013), with comparable rates observed in non-Western populations (Yang et al., 2024). Similarly, approximately 30% experience anxiety disorders within the first year (Rafsten et al., 2018). Despite this, over half of stroke survivors report not receiving help for anxiety or depression, and nearly two-thirds feel their emotional needs are neglected compared to their physical recovery (Stroke Association, 2013).

Evidence-based psychological therapies, such as those provided by NHS Talking Therapies for anxiety and depression (NHS TTad) in England, are the first line treatment for post-stroke depression and post-stroke anxiety (Intercollegiate Stroke Working Party, 2023). A recent analysis of 7597 stroke survivors treated within NHS TTad found that, although symptoms of depression and anxiety improved, stroke survivors were less likely to achieve reliable recovery and more likely to experience reliable deterioration compared to matched patients without

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https://doi.org/10.1016/j.jad.2026.122052
Received 24 September 2025; Received in revised form 20 May 2026; Accepted 27 May 2026
Available online 29 May 2026

a history of stroke. However, adjusting for physical comorbidity reduced the strength of these associations (Suh et al., 2025). These findings highlight the complex treatment needs of this population.

While psychological treatments show promise, they are not universally effective. Meta-analyses of randomised controlled trials (RCTs) evaluating cognitive-behavioural therapy (CBT) for stroke survivors have shown significant reductions in post-stroke anxiety and depression. However, substantial heterogeneity was observed, likely reflecting variation in patient characteristics (Ahrens et al., 2023; Wan et al., 2024).

Some of this heterogeneity is likely due to stroke-specific factors. Hemiplegia, a condition characterised by paralysis of the arm and leg on one side of the body, can be used to assess stroke severity (Kogan et al., 2020). Stroke severity consistently predicts post-stroke anxiety and depression (Menlove et al., 2015; Hackett and Anderson, 2005; Yang et al., 2024). Additionally, 71% of post-stroke depression cases develop within the first three months post-stroke, underlining the need for timely intervention (Liu et al., 2023). Supporting this, stroke survivors who began NHS TTad treatment a year or more after stroke were less likely to reliably recover from depression or anxiety compared to those treated within six months (Suh et al., 2025). Physical comorbidities, present in 75–99% of stroke survivors (Ruksakulpiwat et al., 2023), significantly affect mental health outcomes (e.g., Huang et al., 2023; Xiao et al., 2022). Despite these known associations, previous work has not been adequately powered to provide detailed investigation into how these factors interact to affect psychological outcomes. Given the unique needs of stroke survivors and variability in outcomes, personalised approaches to treatment selection are needed to optimise care and treatment outcomes (Deisenhofer et al., 2024).

Personalised medicine approaches are widely used across healthcare to tailor treatment based on individual characteristics. In stroke care, patient classification has been used to guide rehabilitation intensity (Uchida et al., 2023). In mental health, similar approaches have been used to identify classes of patients at greater risk of deterioration or dropout from treatment (Saunders et al., 2016). One method for identifying such classes is latent class analysis (LCA), a statistical technique that uncovers unobserved (latent) groups within a population based on shared characteristics. For example, a study of over 16,000 patients used LCA to identify four distinct classes linked to varying symptom trajectories (Skelton et al., 2023). There is potential to apply LCA to stroke survivors by incorporating stroke-specific clinical characteristics to enhance mental health treatment selection and outcomes. Unlike previous studies focused on single predictors, LCA captures the intersectionality of multiple factors within a single model (Singham et al., 2022). It remains unclear whether stroke-related clinical characteristics available in routine administrative data are sufficient to meaningfully stratify survivors by psychological treatment prognosis.

The present study applied LCA to a large dataset of stroke survivors with depression and anxiety disorders receiving psychological treatment from national psychological treatment services. The aim was to identify distinct classes of patients based on stroke-related characteristics, such as type of stroke and physical co-morbidities, and to investigate whether treatment outcomes vary among these groups. The study also explored whether therapy intensity (high-intensity vs. low-intensity) was associated with differences in outcomes across the identified classes.

2. Methods

This study was conducted in accordance with a pre-registered protocol and analysis plan https://osf.io/dtbh3. This study was reported in accordance with the STROBE reporting guideline (Appendix 1).

2.1. Dataset and Services

This study conducted a secondary data analysis using the MODIFY dataset (Stott et al., 2023). The complete dataset included all patients referred to NHS TTad services across all clinical commissioning group (CCG) areas in England from 2012 to 2019. Each NHS TTad referral within the MODIFY dataset was linked to other routinely collected data held in NHS datasets using a unique patient identification key provided by NHS Digital. These datasets included Hospital Episode Statistics (HES), the Mental Health Services Dataset (MHSDS), and HES-ONS (Office of National Statistics) mortality data. A subset of the MODIFY dataset was analysed, including only patients with a recorded stroke diagnosis (International Classification of Diseases 10th Revision [ICD-10] codes I60-I64) identified in HES or MHSDS prior to their NHS TTad assessment date.

NHS TTad services are primary care services offering evidence-based low-intensity (LI) and high-intensity (HI) psychological therapies for depression and anxiety disorders. LI therapies include computerised and clinician-facilitated self-help interventions, primarily based on CBT approaches, designed for presentations with lower support needs (formerly referred to as ‘mild-to-moderate’) for which there is a National Institute of Health and Care Excellence (NICE) recommended LI intervention. HI therapies are used for presentations with greater support needs (formerly ‘moderate-to-severe’) or for disorders for which there is no NICE recommended LI treatment (e.g., obsessive-compulsive disorder [OCD], social anxiety disorder, health or illness anxiety disorder, and posttraumatic stress disorder [PTSD]). HI therapies include clinician-led CBT, counselling for depression (CfD), interpersonal psychotherapy (IPT), behavioural couples' therapy (BCT), and eye movement desensitisation and reprocessing (EMDR) among others. LI or HI treatment allocation is determined based on clinical severity measures collected during the initial assessment. Patients could also be stepped up from LI to HI treatment based on clinical need. The services are free at the point of access, and available across England through self or physician referral. NHS TTad is supported through routine data submissions from NHS service providers (e.g., NHS England, 2024b).

2.2. Participants

The study included patients aged 18 or over who were treated in NHS TTad services across England between 2012 and 2019 and had a documented stroke diagnosis in hospital or secondary care mental health records prior to their NHS TTad assessment. Eligibility required baseline scores above clinical ‘caseness’ thresholds (indicating clinically significant symptoms) for depression or anxiety, measured by the 9-item Patient Health Questionnaire (PHQ-9), Generalised Anxiety Disorder 7-item scale (GAD-7), or an Anxiety Disorder Specific Measure (ADSM) (Appendix 5). Patients must have attended at least two psychological treatment sessions and have been discharged at the point data were transferred to NHS Digital. This is how NHS Digital defines the completion of a course of TTad treatment (NHS England, 2024a). Patients with incomplete outcome data or missing end-of-treatment dates (indicating they were still in active treatment) were excluded. For individuals with multiple TTad treatment episodes following their stroke, only the first episode was analysed. Exclusions made to the dataset are detailed in Appendix 2 and missing data is outlined in Appendix 3.

2.3. Measures

NHS TTad services are mandated to routinely collect outcome measures of depression and anxiety at every clinical contact. Nationally, there is approximately 99% coverage in pre and post treatment data for these measures (Clark, 2018). Table 1 outlines the measures and additional data items that were included in the analyses, some of which are self-reported in NHS TTad, while others are derived from HES and MHSDS, as indicated in the ‘Data Source’ column.

2.3.1. Outcomes

The primary outcome was reliable recovery. Secondary outcomes included reliable improvement, reliable deterioration, and dropout.

Table 1
Available data and measures.

Data item	Data source	Description
Demographic Information	NHS TTad	Includes self-reported gender, age, ethnicity (based on UK ONS codes: Asian, Black, Chinese, Mixed, Other, White), employment status, and IMD deciles (1% = most deprived; 10% = least deprived 10%).
Baseline Mental Health Diagnosis	NHS TTad	Primary ICD-10 diagnosis targeted by TTad treatment, although other conditions may also be present. Categories include depression, mixed anxiety & depression, GAD, OCD, PTSD, phobic anxiety, panic, and unspecified anxiety disorder.
Medications	NHS TTad	Psychotropic medication status recorded at every clinical contact: prescribed and not taking, prescribed and taking, not prescribed.
Physical Comorbidities	HES and MHSDS	Comorbidities measured before therapy began, selected largely based on the Ischaemic Stroke adapted Charlson Comorbidity Index (ISCCI) (Hall et al., 2019). Comorbidities were categorised into: heart disease, cancer, diabetes, and other. Full ICD-10 code lists are provided in Appendix 4.
Type of Stroke	HES and MHSDS	Ischaemic stroke (ICD-10 code = I63) or haemorrhagic stroke (ICD-10 codes I60-I62).
Diagnosis of Hemi/Paraplegia	HES and MHSDS	Hemiplegia (paralysis of one side of the body), paraplegia (paralysis of both legs), and other paralytic syndromes grouped together to serve as a proxy for post-stroke physical disability. Prevalence and ICD-10 codes are reported in Appendix 6.
Treatment Factors	NHS TTad	Includes intensity (LI or HI) and type of treatment received, number of sessions, time from referral to assessment, time from assessment to first treatment, and time from stroke diagnosis to treatment initiation.
Depression Measure	NHS TTad	PHQ-9 is a self-administered 9-item depression screening tool (Kroenke et al., 2001). Caseness thresholds and reliable change criteria for each measure are provided in Appendix 5.
Anxiety Measure	NHS TTad	GAD-7 is used as the default measure where no paired ADSM is available (Spitzer et al., 2006). ADSMs are used for specific disorder presentations. Caseness thresholds and reliable change criteria for each measure are provided in Appendix 5.

***Note*.** GAD-7 = Generalised Anxiety Disorder 7-item scale; HES = Hospital Episode Statistics; HI = high-intensity; ICD-10 = International Classification of Diseases, 10th Revision; IMD = Index of Multiple Deprivation; LI = low-intensity; MHSDS = Mental Health Services Dataset; NHS TTad = NHS Talking Therapies for anxiety and depression; OCD = obsessive-compulsive disorder; ONS = Office for National Statistics; PHQ-9 = Patient Health Questionnaire-9; PTSD = post-traumatic stress disorder.

A patient was classified as having reliably recovered if their symptoms met criteria for both recovery and reliable improvement. Recovery required scores above the caseness threshold at the start of treatment and below it on both depression (PHQ-9) and anxiety (GAD-7 or ADSM) measures at the end of treatment (NHS England, 2024a).

Reliable improvement was indicated if scores on the depression and/or anxiety measure decreased by a psychometrically reliable amount (the reliable change threshold) pre-to-post treatment, with no reliable increase in either measure. Reliable deterioration was indicated if scores increased by a psychometrically reliable amount, with no reliable decrease on either measure. Where reliable improvement occurred on one measure and deterioration on the other, this was classified as “no reliable change” (NHS England, 2024a). Reliable change thresholds for each measure are specified in Appendix 5.

Dropout was recorded where a patient discontinued or declined further treatment after attending at least two sessions. This is recorded by the clinician via the mandatory “reason for ending the care episode” field in NHS TTad at the point of discharge.

2.4. Plan of analysis

2.4.1. Latent class analysis (LCA)

LCA was performed using four pre-treatment characteristics: type of stroke (ischaemic or haemorrhagic, each as binary indicator variables), time from stroke diagnosis to psychological treatment initiation, diagnosis of hemiplegia/paraplegia, and physical comorbidities. Physical comorbidities were included as separate variables, with binary indicators for heart disease, cancer, diabetes, and a grouped category of other conditions (Appendix 4). Established stroke-related factors such as cognitive impairment and language deficits were not available in the MODIFY dataset as LCA indicators.

Supplementary variables not directly modelled but used to provide additional context for the analysis included age, ethnicity, gender, local area deprivation, baseline PHQ-9 and GAD-7 scores, employment status, benefit status (whether the patient was receiving government benefits) and medication status. Full Information Maximum Likelihood estimation was used to handle missing data, allowing all observations with at least one latent class indicator available to be included in the analysis. Analyses were conducted using Mplus version 8.2 (L. K. Muthén and Muthén, 1998).

Model fit was evaluated using the Vuong-Lo-Mendell-Rubin Likelihood Ratio Test (VLMR-LRT) (Lo et al., 2001), Bootstrap Likelihood Ratio Test (B-LRT), Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), average posterior probabilities, and entropy values. In addition, we adopted the restriction that at least 5% of the sample were required to make up each class, to ensure solutions were clinically meaningful (Smyth et al., 2022; Spinhoven et al., 2016). The analysis began with a two-class model, progressively adding more classes while considering all fit indices. The VLMR-LRT and B-LRT compares each K-class model with its K-1 counterpart; if the results of these tests are no longer significant, that indicates that adding more classes does not improve model fit (Geiser, 2013; Muthén and Asparouhov, 2012). Lower AIC/BIC values signify improved model fit, while higher entropy values indicate greater classification accuracy (B. Muthén and Muthén, 2000; Nylund et al., 2007). Average posterior probabilities of at least 0.80 were considered acceptable for adequate classification accuracy (Weller et al., 2020).

2.4.2. Associations between latent classes and psychological treatment outcomes

Differences in psychological treatment outcomes between latent classes were examined using the distal categorical outcome (DCAT) method in MPlus (L. K. Muthén and Muthén, 1998). This approach accounts for classification uncertainty by incorporating posterior class membership probabilities rather than relying on modal class assignment. Differences in outcome probabilities between classes were evaluated using chi-square tests, with pairwise comparisons conducted between all classes.

2.4.3. Treatment outcomes by intensity of intervention

Treatment outcomes were compared between individuals receiving LI and HI psychological interventions, adjusting for baseline differences in PHQ-9 and GAD-7. Only patients treated exclusively with one intervention intensity were included; those stepped-up during treatment or with missing intensity data were excluded. Logistic regression analyses were used to calculate odds ratios and 95% confidence intervals ‘OR (95% CI)’ for reliable recovery, improvement, deterioration, and dropout between LI and HI interventions within each class. Treatment outcomes were compared between the two intensities for each latent class, with the intensity of intervention serving as the independent variable.

2.5. Ethical approvals

Ethical approval for MODIFY was granted by the UCL Clinical, Educational, and Health Psychology Departmental Research Ethics Committee (REC) (Approval number: CEHP/2023/592B).

3. Results

3.1. Latent class analysis

The study sample included 6349 patients diagnosed with stroke before the start of therapy. 99% of patients received the diagnosis before the date of referral to NHS TTad. The characteristics of these patients are detailed in the first column of Table 2.

In the LCA, the VLMR-LRT and B-LRT yielded significant *p*-values ($p < 0.05$) when comparing models with two to five classes, and AIC and BIC values decreased with additional classes. However, the five-class model included one class representing fewer than 5% of the sample ($n = 285$), raising concerns about model stability and interpretability. Therefore, the four-class solution was selected.

Table 2
Latent classes and associated patient characteristics.

	Full sample	LC1	LC2	LC3	LC4
Count – n (%)	6349 (100)	703 (11.1)	3349 (52.7)	1260 (19.8)	1037 (16.3)
Demographics					
Mean age (SD)	58.1 (14.3)	63.3 (13.3)	58.5 (13.9)	53.6 (14.3)	58.4 (14.7)
Females – n (%)	3321 (52.3)	321 (45.7)	1690 (50.5)	765 (60.7)	545 (52.6)
Ethnicity					
White – n (%)	5238 (82.5)	567 (80.7)	2782 (83.1)	1023 (81.2)	866 (83.7)
Asian – n (%)	240 (3.8)	29 (4.1)	105 (3.1)	70 (5.6)	36 (3.5)
Black – n (%)	175 (2.8)	24 (3.4)	81 (2.4)	46 (3.7)	24 (2.3)
Mixed – n (%)	71 (1.1)	7 (1.0)	34 (1.0)	15 (1.2)	15 (1.4)
Other– n (%)	52 (0.8)	5 (0.7)	25 (0.7)	14 (1.1)	8 (0.8)
Chinese – n (%)	8 (0.1)	2 (0.3)	3 (0.1)	3 (0.2)	0 (0)
Employed – n (%)	4169 (65.7)	454 (64.6)	2275 (67.9)	800 (63.5)	640 (61.7)
No benefits – n (%)	4350 (68.5)	472 (67.1)	2363 (70.6)	841 (66.7)	674 (65.0)
Mean baseline PHQ9 score (SD)	15.8 (5.5)	16.6 (5.4)	15.6 (5.5)	15.3 (5.4)	16.2 (5.6)
Mean end PHQ9 score (SD)	8.7 (6.5)	9.3 (6.8)	5.6 (6.5)	8.6 (6.4)	9.0 (6.7)
Mean baseline GAD7 score (SD)	13.4 (4.9)	13.4 (5.0)	13.4 (4.8)	13.4 (4.7)	13.3 (5.0)
Mean end GAD7 score (SD)	7.4 (5.7)	7.6 (5.9)	7.3 (5.7)	7.7 (5.7)	7.3 (5.8)
Clinical characteristics included in LCA model					
Ischaemic stroke – n (%)	4385 (69.1)	623 (88.6)	3066 (91.5)	0 (0)	696 (67.1)
Haemorrhagic stroke – n (%)	1765 (27.8)	67 (9.5)	150 (4.5)	1260 (100)	288 (27.8)
Hemiplegia /paraplegia – n (%)[a]	685 (10.8)	278 (39.5)	227 (6.8)	76 (6.0)	104 (10.0)
Heart disease – n (%)	653 (10.3)	366 (52.1)	144 (4.3)	46 (3.7)	97 (9.4)
Diabetes – n (%)	653 (10.3)	294 (41.8)	167 (5.0)	57 (4.5)	135 (13.0)
Cancer – n (%)	311 (4.9)	137 (19.5)	80 (2.4)	41 (3.3)	53 (5.1)
Other co-morbidity – n (%)	1585 (25.0)	603 (85.8)	465 (13.9)	234 (18.6)	283 (27.3)
Mean days from stroke diagnosis to treatment (SD)	586.1 (508.0)	446.1 (316.2)	385.7 (294.2)	441.4 (320.1)	1504.2 (311.7)

Note. PHQ-9 = 9-item Patient Health Questionnaire; GAD-7 = Generalised Anxiety Disorder 7-item scale.

[a] Prevalences of hemiplegia and paraplegia reported in Appendix 6.

Model fit statistics and classification accuracy values are provided in Appendix 7. The entropy value for the four-class solution was 0.788, and average posterior probabilities ranged from 0.805 to 0.956, indicating adequate accuracy (Weller et al., 2020). Descriptive statistics for each class are presented in Table 2.

LC1, the smallest group (11%), had a high prevalence of ischaemic stroke (89%) and the highest rates of hemiplegia/paraplegia (40%) and comorbidity (52% heart disease, 42% diabetes, 20% cancer, 86% other). The mean time to treatment was similar to that of LC3 (approximately 15 months; 446 days).

LC2 represented the largest group, comprising 53% of the sample. This class was characterised by a predominance of ischaemic stroke (92%), a low prevalence of hemiplegia/paraplegia (7%), and minimal physical comorbidity (4% heart disease, 5% diabetes, 2% cancer, 14% other). Compared with other classes, LC2 had the highest rate of ischaemic stroke, the lowest rates of hemiplegia/paraplegia, cancer, and 'other' comorbidity, and the shortest mean average time from stroke diagnosis to treatment (approximately 13 months; 386 days).

The next largest class, LC3 (20% of the sample), was exclusively associated with haemorrhagic stroke (100%) and had a similarly low prevalence of hemiplegia/paraplegia (6%) and comorbidity (4% heart disease, 5% diabetes, 3% cancer, 19% other) as LC2. The mean average time to treatment was approximately 15 months (441 days).

LC4 included 16% of patients, predominantly with ischaemic stroke (67%). This group showed slightly higher rates of hemiplegia/paraplegia (10%) and comorbidity (9% heart disease, 13% diabetes, 5% cancer, 27% other) and experienced the longest mean average time from stroke diagnosis to treatment (approximately 4 years; 1504 days).

3.2. Treatment outcomes across classes

The association between class membership and treatment outcomes was assessed. Table 3 shows the observed outcome rates for each latent class. Odds ratios from DCAT analyses are presented in Appendix 8.

Reliable recovery rates were above the national average for all TTad cases (approximately 50%; NHS England, 2024a) across all classes, with LC2 having the highest recovery rate (55%). In contrast, LC1 had the lowest recovery rate (50%). DCAT analyses revealed that LC1 had significantly lower odds of reliable recovery compared to LC2 (χ^2 (1) = 12.85, $p < 0$ 0.001), LC3 (χ^2 (1) = 5.59, $p < 0.05$), and LC4 (χ^2 (1) = 4.10, $p < 0.05$).

Reliable improvement rates were also high across classes, with LC2 demonstrating the highest improvement rate (75%). LC1 had significantly lower odds of reliable improvement compared to LC2 (χ^2 (1) = 4.29, $p < 0.05$). No other pairwise comparison reached statistical significance.

Reliable deterioration ranged from 5% in LC4 to 8% in LC1. LC1 had significantly higher odds of deterioration compared to LC2 (χ^2 (1) = 7.06, $p < 0$ 0.01) and LC4 (χ^2 (1) = 5.02, $p < 0.05$).

Dropout rates were relatively consistent, ranging from 26.5% in LC2 to 28% in LC4, with no statistically significant differences across the classes.

3.3. Outcomes by treatment intensity

Finally, the analysis examined whether outcomes differed between patients referred to LI or HI pathways for each latent class, adjusting for baseline differences in depression and anxiety (Appendix 9). After applying the exclusion criteria, the new sample size was 5517. Appendix 10 shows the ORs for treatment outcomes in the HI group compared to the LI group within each latent class.

Across latent classes, higher treatment intensity was generally not

Table 3
The rates of psychological treatment outcomes in each latent class.

Class	Reliable Recovery – n (%)	Reliable Improvement – n (%)	Reliable Deterioration – n (%)	Dropout – n (%)
Full sample	3397 (53.5)	4756 (74.9)	381 (6.0)	1717 (27.0)
1	352 (50.1)	519 (73.8)	56 (8.0)	196 (27.9)
2	1833 (54.7)	2522 (75.3)	188 (5.6)	888 (26.5)
3	669 (53.1)	939 (74.5)	81 (6.4)	339 (26.9)
4	543 (52.4)	776 (74.8)	56 (5.4)	294 (28.4)

significantly associated with reliable recovery, improvement, or deterioration. However, it was associated with lower odds of dropout in several classes. In LC2, patients receiving HI treatment had 23% lower odds of dropping out compared to those receiving LI treatment (OR = 0.77, 95% CI [0.65, 0.92], $p < 0.01$). Similarly, in LC3 and LC4, HI treatment was associated with 38% lower odds (OR = 0.62, 95% CI [0.47, 0.82], $p < 0.01$) and 35% lower odds (OR = 0.65, 95% CI [0.49, 0.87], $p < 0.01$), respectively. For LC1, treatment intensity did not significantly affect any outcomes, including dropout.

4. Discussion

Using LCA, we identified four statistically distinct classes of stroke survivors receiving psychological therapies from a sample of over 6000 patients. Treatment outcomes were similar broadly across these classes, suggesting that the stroke-related variables available in routine administrative records may be insufficient on their own to meaningfully stratify stroke survivors by psychological treatment prognosis.

LC1 was predominantly defined by ischaemic stroke but with a high incidence of hemiplegia/paraplegia and comorbid conditions such as heart disease and diabetes. Patients in LC1 had significantly lower odds of recovery compared to all other classes, lower odds of reliable improvement compared to LC2, and higher odds of reliable deterioration compared to LC2 and LC4. Higher treatment intensity was not associated with better outcomes for LC1. These findings may reflect the higher incidence of physical comorbidity in LC1, which is known to negatively impact mental health outcomes (Huang et al., 2023; Xiao et al., 2022). However, these findings are exploratory and further research is needed to identify which patients are less likely to benefit from psychological treatment, particularly given that this remains a challenge in clinical practice (Hannan et al., 2005).

LC2 was defined primarily by individuals with ischaemic stroke and a low prevalence of hemi/paraplegia and physical comorbidity. LC2 demonstrated better psychological therapy outcomes compared to the full sample and other classes. This group also had the shortest time between stroke diagnosis and initiation of psychological treatment (13 months), possibly reflecting their lower levels of stroke-related disability and comorbidity, rather than representing an independent predictor of outcomes. However, this pattern is consistent with evidence that earlier access to treatment is associated with better outcomes in stroke survivors (Suh et al., 2025).

Dropout in the present study (27–28%) was slightly lower than the reported average across NHS TTad services (31%; Furlong-Silva, 2020), though dropout is consistently linked to poorer outcomes (Cahill et al., 2003; Zieve et al., 2019). HI treatment was associated with reduced dropout risk across LC2-LC4. However, as treatment intensity in NHS TTad is clinically determined, this association should not be interpreted causally; patients allocated to HI treatment may differ from LI patients beyond baseline symptom severity. Nonetheless, this finding is consistent with evidence that increased session frequency is associated with lower dropout and better outcomes in adults with depression (Bruijniks et al., 2020).

4.1. Limitations

This study used UK-specific healthcare data, limiting generalisability to other healthcare systems with differing demographics, healthcare delivery, and socio-economic contexts. However, stroke severity and functional impairment have been identified as predictors of post-stroke depression in non-Western settings, suggesting some consistency in risk factors (Yang et al., 2024).

This study only included stroke survivors referred to NHS TTad, potentially excluding individuals in need who were not referred. Although NHS TTad accepts self-referrals and professional referrals, referral biases may exist. As engagement in structured psychological therapy is required in NHS TTad, those with cognitive or communication difficulties may be under-represented.

A key limitation is that direct measures of cognitive impairment and language deficits were unavailable in the dataset and could not be included in the LCA, despite their plausible association with engagement and outcomes (Fridriksson and Hillis, 2021; Kapoor et al., 2019). Hemiplegia and paraplegia were included as a proxy for stroke severity, which correlates with cognitive impairment (Kogan et al., 2020). However, the heterogeneity of stroke presentations means this is an imperfect proxy. For example, language impairment is more common with right-sided hemiplegia and less frequently co-occurs with left-sided hemiplegia (Anderlini et al., 2019), and anterior communicating artery strokes frequently lead to frontal-executive deficits without motor impairment (Martinaud et al., 2009). Therefore, stroke survivors with potentially severe cognitive or language difficulties but without hemi/paraplegia, may be poorly represented by the identified classes. Future research incorporating measures of language and cognition – for example through linkage to neuropsychological assessment records – could produce classes with greater clinical differentiation.

While the PHQ-9 is validated for stroke survivors (Williams et al., 2005), the GAD-7 has not been specifically validated in this population. It is possible that the GAD-7 systematically under- or overestimates anxiety symptom change in stroke survivors, which may affect the accuracy of findings. More stroke-specific tools, such as the Stroke Aphasia Anxiety and Mood Screen, may be more suitable, particularly for individuals with communication difficulties (Murphy et al., 2024).

The treatment intensity analysis has several limitations. Data on treatment fidelity or adaptations were not available, limiting insights into which specific aspects of treatment were effective. The broad categorisation of treatment into LI and HI also means the study cannot determine which specific therapy types were most effective for each class. Additionally, patients stepped up from LI to HI treatment were excluded. These patients may represent a clinically distinct subgroup, and so findings may not generalise to this group.

Finally, the large number of comparisons increases the possibility of Type I error. However, no corrections for multiple comparisons were applied, consistent with recommendations for exploratory research (Rothman, 1990). Findings are presented irrespective of statistical significance, reducing the risk of p-hacking while acknowledging that some Type I errors may remain (Head et al., 2015).

5. Conclusions

LCA was used to identify four distinct classes of stroke survivors in treatment for depression and anxiety, based on stroke type, time from stroke diagnosis to treatment, hemiplegia/paraplegia, and physical comorbidities. There were limited differences in psychological treatment outcomes across classes. These findings suggest that stroke-related variables available in routine administrative health records may be insufficient on their own to meaningfully stratify stroke survivors by treatment prognosis. Nonetheless, these findings challenge therapeutic nihilism within services, particularly among therapists and service commissioners. No class fell below anticipated recovery rates (NHS England, 2024a), suggesting that psychological interventions in NHS TTad can be beneficial even for those perceived as higher risk. Additional patient-level data, such as measures of cognitive function and language impairment, may be necessary to develop more clinically informative subgrouping. Future research incorporating such variables could advance personalised approaches to mental health care for stroke survivors.

CRediT authorship contribution statement

Lucy Gallagher: Writing – original draft, Methodology, Formal analysis, Conceptualization. **Rob Saunders:** Writing – review & editing, Supervision, Project administration, Methodology, Data curation, Conceptualization. **Joshua E.J. Buckman:** Writing – review & editing, Methodology. **Vaughan Bell:** Writing – review & editing, Methodology. **Céline El Baou:** Writing – review & editing, Methodology, Data curation. **Stephen Pilling:** Writing – review & editing, Methodology. **Amber John:** Writing – review & editing, Methodology, Data curation. **Joshua Stott:** Writing – review & editing, Methodology, Funding acquisition. **Jae Won Suh:** Writing – review & editing, Supervision, Project administration, Methodology, Formal analysis, Data curation, Conceptualization.

Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees.

Financial support

The MODIFY Project was supported by the Alzheimer's Society (grant number AS-PG-18-013).

Declaration of competing interest

C.E.B. has been a statistical consultant to Eli Lilly and Company in an unrelated role. R.S. held an unrelated honorary position with NHS England on an unrelated project; time was compensated through financial support to the employing institution. J.S. has been a consultant to NHS Wales Shared Services Partnership and is involved in unrelated research projects funded by NIHR Public Health Research, Dunhill Medical Trust and ESRC/NIHR. RS, JEJB and SP received funding from Royal College of Psychiatrists and from NIHR for unrelated project. JEJB received funding from MRC for unrelated project. RS received funding from ESRC for unrelated project. The remaining authors declare no competing interests.

Acknowledgements

C.E.B., J.S. and A.J. are supported by the Alzheimer's Society (AS-PG-18-013). J.E.J.B., S.P. and R.S. are supported by the Royal College of Psychiatrists. J.S. and S.P. are supported by National Institute of Health Research University College London Hospital Biomedical Research Centre. The funders of the study had no role in study design, data analysis, data interpretation, writing of the report or decision to submit this article for publication.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2026.122052.

References

Ahrens, J., Shao, R., Blackport, D., Macaluso, S., Viana, R., Teasell, R., Mehta, S., 2023. Cognitive -behavioral therapy for managing depressive and anxiety symptoms after stroke: a systematic review and meta-analysis. Top. Stroke Rehabil. 30 (4), 368–383. https://doi.org/10.1080/10749357.2022.2049505.

Anderlini, D., Wallis, G., Marinovic, W., 2019. Language as a predictor of motor recovery: the case for a more global approach to stroke rehabilitation. Neurorehabil. Neural Repair 33 (3), 167–178. https://doi.org/10.1177/1545968319829454.

Ayerbe, L., Ayis, S., Wolfe, C.D.A., Rudd, A.G., 2013. Natural history, predictors and outcomes of depression after stroke: systematic review and meta-analysis. Br. J. Psychiatry J. Ment. Sci. 202 (1), 14–21. https://doi.org/10.1192/bjp.bp.111.107664.

Bruijniks, S.J.E., Lemmens, L.H.J.M., Hollon, S.D., Peeters, F.P.M.L., Cuijpers, P., Arntz, A., Dingemanse, P., Willems, L., Oppen, P. van, Twisk, J.W.R., Boogaard, M. van den, Spijker, J., Bosmans, J., Huibers, M.J.H., 2020. The effects of once- versus twice-weekly sessions on psychotherapy outcomes in depressed patients. Br. J. Psychiatry 216 (4), 222–230. https://doi.org/10.1192/bjp.2019.265.

Cahill, J., Barkham, M., Hardy, G., Rees, A., Shapiro, D.A., Stiles, W.B., Macaskill, N., 2003. Outcomes of patients completing and not completing cognitive therapy for depression. Br. J. Clin. Psychol. 42 (2), 133–143. https://doi.org/10.1348/014466503321903553.

Clark, D.M., 2018. Realizing the mass public benefit of evidence-based psychological therapies: the IAPT program. Annu. Rev. Clin. Psychol. 14, 159–183. https://doi.org/10.1146/annurev-clinpsy-050817-084833.

Deisenhofer, A.-K., Barkham, M., Beierl, E.T., Schwartz, B., Aafjes-van Doorn, K., Beevers, C.G., Berwian, I.M., Blackwell, S.E., Bockting, C.L., Brakemeier, E.-L., Brown, G., Buckman, J.E.J., Castonguay, L.G., Cusack, C.E., Dalgleish, T., de Jong, K., Delgadillo, J., DeRubeis, R.J., Driessen, E., Ehrenreich-May, J., Fisher, A.J., Fried, E.I., Fritz, J., Furukawa, T.A., Gillan, C.M., Gomez Penedo, J.M., Hitchcock, P. F., Hofmann, S.G., Hollon, S.D., Jacobson, N.C., Karlin, D.R., Lee, C.T., Levinson, C. A., Lorenzo-Luaces, L., McDanal, R., Moggia, D., Ng, M.Y., Norris, L.A., Patel, V., Piccirillo, M.L., Pilling, S., Rubel, J.A., Salazar-de-Pablo, G., Schleider, J.L., Schnurr, P.P., Schueller, S.M., Siegle, G.J., Uher, R., Watkins, E., Webb, C.A., Wiltsey Stirman, S., Wynants, L., Youn, S.J., Zilcha-Mano, S., Lutz, W., Cohen, Z.D., 2024. Implementing precision methods in personalizing psychological therapies: Barriers and possible ways forward. Behav. Res. Ther. 172, 104443. https://doi.org/10.1016/j.brat.2023.104443.

Fridriksson, J., Hillis, A.E., 2021. Current approaches to the treatment of post-stroke aphasia. J. Stroke 23 (2), 183–201. https://doi.org/10.5853/jos.2020.05015.

Furlong-Silva, J., 2020. *Exploring factors related to and predictors of dropout in Improving Access to Psychological Therapies (IAPT) services: A systematic review and secondary analysis of the PRaCTICED data.* [Dclinpsy, University of Sheffield]. https://etheses.whiterose.ac.uk/id/eprint/27699/.

Geiser, C., 2013. Data Analysis With Mplus (pp. xiii, 305). Guilford Press.

Hackett, M.L., Anderson, C.S., 2005. Predictors of depression after stroke. Stroke 36 (10), 2296–2301. https://doi.org/10.1161/01.STR.0000183622.75135.a4.

Hall, R.E., Porter, J., Quan, H., Reeves, M.J., 2019. Developing an adapted Charlson comorbidity index for ischemic stroke outcome studies. BMC Health Serv. Res. 19 (1), 930. https://doi.org/10.1186/s12913-019-4720-y.

Hannan, C., Lambert, M.J., Harmon, C., Nielsen, S.L., Smart, D.W., Shimokawa, K., Sutton, S.W., 2005. A lab test and algorithms for identifying clients at risk for treatment failure. J. Clin. Psychol. 61 (2), 155–163. https://doi.org/10.1002/jclp.20108.

Head, M.L., Holman, L., Lanfear, R., Kahn, A.T., Jennions, M.D., 2015. The extent and consequences of P-Hacking in science. PLoS Biol. 13 (3), e1002106. https://doi.org/10.1371/journal.pbio.1002106.

Huang, Y., Loux, T., Huang, X., Feng, X., 2023. The relationship between chronic diseases and mental health: a cross-sectional study. Ment. Health Prevent. 32. https://doi.org/10.1016/j.mhp.2023.200307.

Intercollegiate Stroke Working Party, 2023. National Clinical Guideline for Stroke. https://www.strokeguideline.org/.

Kapoor, A., Lanctot, K.L., Bayley, M., Herrmann, N., Murray, B.J., Swartz, R.H., 2019. Screening for post-stroke depression and cognitive impairment at baseline predicts long-term patient-centered outcomes after stroke. J. Geriatr. Psychiatry Neurol. 32 (1), 40–48. https://doi.org/10.1177/0891988718819859.

Kogan, E., Twyman, K., Heap, J., Milentijevic, D., Lin, J.H., Alberts, M., 2020. Assessing stroke severity using electronic health record data: a machine learning approach. BMC Med. Inform. Decis. Mak. 20 (1), 8. https://doi.org/10.1186/s12911-019-1010-x.

Kroenke, K., Spitzer, R.L., Williams, J.B.W., 2001. The PHQ-9: validity of a brief depression severity measure. J. Gen. Intern. Med. 16 (9), 606–613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x.

Liu, L., Xu, M., Marshall, I.J., Wolfe, C.D., Wang, Y., O'Connell, M.D., 2023. Prevalence and natural history of depression after stroke: a systematic review and meta-analysis of observational studies. PLoS Med. 20 (3), e1004200. https://doi.org/10.1371/journal.pmed.1004200.

Lo, Y., Mendell, N.R., Rubin, D.B., 2001. Testing the number of components in a normal mixture. Biometrika 88 (3), 767–778. https://doi.org/10.1093/biomet/88.3.767.

Martinaud, O., Perin, B., Gérardin, E., Proust, F., Bioux, S., Gars, D.L., Hannequin, D., Godefroy, O., 2009. Anatomy of executive deficit following ruptured anterior communicating artery aneurysm. Eur. J. Neurol. 16 (5), 595–601. https://doi.org/10.1111/j.1468-1331.2009.02546.x.
Menlove, L., Crayton, E., Kneebone, I., Allen-Crooks, R., Otto, E., Harder, H., 2015. Predictors of anxiety after stroke: A systematic review of observational studies. J. Stroke Cerebrovasc. Dis. 24 (6), 1107–1117. https://doi.org/10.1016/j.jstrokecerebrovasdis.2014.12.036.
Murphy, D., Hourston, J., Freeman, E., Hawker, N., Morris-Haynes, R., 2024. An evaluation of the validity of an aphasia friendly mood and anxiety measure for stroke patients. Aphasiology 39 (4), 500–513. https://doi.org/10.1080/02687038.2024.2361512.
Muthén, B., Asparouhov, T., 2012. Bayesian structural equation modeling: a more flexible representation of substantive theory. Psychol. Methods 17 (3), 313–335. https://doi.org/10.1037/a0026802.
Muthén, L.K., Muthén, B.O., 1998. Mplus User's Guide, eighth edition.
Muthén, B., Muthén, L.K., 2000. Integrating person-centered and variable-centered analyses: growth mixture modeling with latent trajectory classes. Alcohol. Clin. Exp. Res. 24 (6), 882–891. https://doi.org/10.1111/j.1530-0277.2000.tb02070.x.
NHS England, 2024a. NHS Talking Therapies for Anxiety and Depression Manual. https://www.england.nhs.uk/publication/the-improving-access-to-psychological-therapies-manual/.
NHS England, 2024b. NHS Talking Therapies Monthly Statistics Including Employment Advisors, Performance. NHS England Digital. https://digital.nhs.uk/data-and-information/publications/statistical/nhs-talking-therapies-monthly-statistics-including-employment-advisors/performance-april-2024.
Nylund, K.L., Asparouhov, T., Muthén, B.O., 2007. Deciding on the number of classes in latent class analysis and growth mixture modeling: a Monte Carlo simulation study. Struct. Equ. Model. Multidiscip. J. 14 (4), 535–569. https://doi.org/10.1080/10705510701575396.
Rafsten, L., Danielsson, A., Sunnerhagen, K.S., 2018. Anxiety after stroke: a systematic review and meta-analysis. J. Rehabil. Med. 50(9), Article 9. https://doi.org/10.2340/16501977-2384.
Rothman, K.J., 1990. No adjustments are needed for multiple comparisons. Epidemiology 1 (1), 43–46.
Ruksakulpiwat, S., Zhou, W., Phianhasin, L., Benjasirisan, C., Salehizadeh, S., Wang, L., Voss, J.G., 2023. Associations between diagnosis with stroke, comorbidities, and activity of daily living among older adults in the United States. Chronic Dis. Transl. Med. 9 (2), 164–176. https://doi.org/10.1002/cdt3.60.
Saunders, R., Cape, J., Fearon, P., Pilling, S., 2016. Predicting treatment outcome in psychological treatment services by identifying latent profiles of patients. J. Affect. Disord. 197, 107–115. https://doi.org/10.1016/j.jad.2016.03.011.
Singham, T., Saunders, R., Brooker, H., Creese, B., Aarsland, D., Hampshire, A., Ballard, C., Corbett, A., Desai, R., Stott, J., 2022. Are subtypes of affective symptoms differentially associated with change in cognition over time: a latent class analysis. J. Affect. Disord. 309, 437–445. https://doi.org/10.1016/j.jad.2022.04.139.
Skelton, M., Carr, E., Buckman, J.E.J., Davies, M.R., Goldsmith, K.A., Hirsch, C.R., Peel, A.J., Rayner, C., Rimes, K.A., Saunders, R., Wingrove, J., Breen, G., Eley, T.C., 2023. Trajectories of depression and anxiety symptom severity during psychological therapy for common mental health problems. Psychol. Med. 53 (13), 6183–6193. https://doi.org/10.1017/S0033291722003403.
Smyth, N., Buckman, J.E.J., Naqvi, S.A., Aguirre, E., Cardoso, A., Pilling, S., Saunders, R., 2022. Understanding differences in mental health service use by men: An intersectional analysis of routine data. Soc. Psychiatry Psychiatr. Epidemiol. 57 (10), 2065–2077. https://doi.org/10.1007/s00127-022-02256-4.
Spinhoven, P., Batelaan, N., Rhebergen, D., van Balkom, A., Schoevers, R., Penninx, B. W., 2016. Prediction of 6-yr symptom course trajectories of anxiety disorders by diagnostic, clinical and psychological variables. J. Anxiety Disord. 44, 92–101. https://doi.org/10.1016/j.janxdis.2016.10.011.
Spitzer, R.L., Kroenke, K., Williams, J.B.W., Löwe, B., 2006. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch. Intern. Med. 166 (10), 1092–1097. https://doi.org/10.1001/archinte.166.10.1092.
Stott, J., Saunders, R., Desai, R., Bell, G., Fearn, C., Buckman, J.E.J., Brown, B., Nurock, S., Michael, S., Ware, P., Marchant, N.L., Aguirre, E., Rio, M., Cooper, C., Pilling, S., Richards, M., John, A., 2023. Associations between psychological intervention for anxiety disorders and risk of dementia: a prospective cohort study using national health-care records data in England. Lancet Healthy Longev. 4 (1), e12–e22. https://doi.org/10.1016/S2666-7568(22)00242-2.
Stroke Association, 2013. Feeling Overwhelmed—The Emotional Impact of Stroke. https://www.stroke.org.uk/sites/default/files/feeling_overwhelmed_final_web_0.pdf.
Suh, J.W., Bell, V., Buckman, J.E.J., El Baou, C., Desai, R., Fearn, C., Marchant, N.L., Richards, M., Cooper, C., Pilling, S., John, A., Stott, J., Saunders, R., 2025. A record-linkage study of post-stroke primary care psychological therapy effectiveness in England. Nat. Ment. Health 1–10. https://doi.org/10.1038/s44220-025-00429-z.
Uchida, J., Yamada, M., Nagayama, H., Tomori, K., Ikeda, K., Yamauchi, K., 2023. Prediction of Overall Patient Characteristics that Incorporate Multiple Outcomes in Acute Stroke: Latent Class Analysis (p. 2023.05.24.23290504). medRxiv. https://doi.org/10.1101/2023.05.24.23290504.
Wan, M., Zhang, Y., Wu, Y., Ma, X., 2024. Cognitive behavioural therapy for depression, quality of life, and cognitive function in the post-stroke period: Systematic review and meta-analysis. Psychogeriatrics 24 (4), 983–992. https://doi.org/10.1111/psyg.13125.
Weller, B.E., Bowen, N.K., Faubert, S.J., 2020. Latent class analysis: a guide to best practice. J. Black Psychol. 46 (4), 287–311. https://doi.org/10.1177/0095798420930932.
Williams, L.S., Brizendine, E.J., Plue, L., Bakas, T., Tu, W., Hendrie, H., Kroenke, K., 2005. Performance of the PHQ-9 as a screening tool for depression after stroke. Stroke 36 (3), 635–638. https://doi.org/10.1161/01.STR.0000155688.18207.33.
Xiao, S., Shi, L., Dong, F., Zheng, X., Xue, Y., Zhang, J., Xue, B., Lin, H., Ouyang, P., Zhang, C., 2022. The impact of chronic diseases on psychological distress among the older adults: the mediating and moderating role of activities of daily living and perceived social support. Aging Ment. Health 26 (9), 1798–1804. https://doi.org/10.1080/13607863.2021.1947965.
Yang, F., Zhang, P., Yang, F., Zhang, P., 2024. Prevalence and predictive factors of post-stroke depression in patients with acute cerebral infarction. Alpha Psychiatr. 25 (5), 592–597. https://doi.org/10.5152/alphapsychiatry.2024.231381.
Zieve, G.G., Persons, J.B., Yu, L.A.D., 2019. The relationship between dropout and outcome in naturalistic cognitive behavior therapy. Behav. Ther. 50 (1), 189–199. https://doi.org/10.1016/j.beth.2018.05.004.