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Prevalence and determinants of post-stroke psychosis in Aswan: a prospective study

Bastawy M. Al Fawal[1], Gellan K. Ahmed[2], Ahmed K. Ibrahim[3,4], Mohamed A. Abdelhamed[2] and Nourelhoda A. Haridy[2*]

Abstract

Background Post-stroke psychosis (PSP) is a rare but serious neuropsychiatric condition characterized by delusions and/or hallucinations following a stroke. Despite its impact on prognosis and quality of life, PSP remains underdiagnosed and undertreated, with limited data on its prevalence and risk factors. The purpose of this study is to assess the prevalence and determinants of post-stroke psychosis (PSP), as well as to compare PSP and non-PSP patients in terms of improvement and daily living outcomes. This nested case–control study included 2,624 acute stroke patients from a university hospital between May 2017 and April 2022. Patients who developed PSP within 6 months post-stroke were identified as cases ($n = 108$), and 119 patients without PSP were randomly selected as controls. Comprehensive assessments included clinical, laboratory, and imaging evaluations at baseline. After 6 months, follow-up evaluations were conducted, including neurological examinations, psychiatric assessments, and stroke severity assessments using the Barthel index (BI). The psychiatric assessments included the Hamilton Depression Rating Scale for depression and the Mini-Mental State Examination for cognitive status.

Results The prevalence of PSP was 5.4%. risk factors significantly associated with PSP included older age, male patients, lower education level (≤ 5 years), hemiplegia, sphincter affection, cortical lesion, brain atrophy, small vessel disease, ischemic stroke, post-stroke dementia, and seizures. Non-specified psychosis and delusional disorder were the most common psychosis subtypes. There was a significantly higher percentage of excellent patients in the non-PSP group compared to those who had PSP regarding the observed improvement in the patient's condition. Also, there is a higher percentage of deteriorated patients in the PSP group (46.6%) compared to another group (18.9%) regarding BI.

Conclusion PSP is a prevalent post-stroke complication associated with distinct risk factors and poor functional outcomes. Early screening and identification of high-risk patients, along with multidisciplinary management strategies, are crucial for optimizing recovery and quality of life in stroke survivors.

Keywords Post-stroke psychosis, Hallucination, Delusion, Barthel index

Background

Both stroke and psychosis are considered major and debilitating health disorders [1]. When they co-occur, they form a serious post-stroke syndrome strongly associated with adverse outcomes [2–4]. Multiple terminologies, including atypical psychosis, peduncular hallucinosis, release hallucinations, organic psychosis, and agitated delirium, are commonly used interchangeably to describe post-stroke psychosis (PSP) [5]. PSP is a rare

*Correspondence:
Nourelhoda A. Haridy
nourelhodaahmed@aun.edu.eg
[1] Department of Neurology and Psychiatry, Aswan University, Aswan, Egypt
[2] Department of Neurology and Psychiatry, Faculty of Medicine, Assiut University, Assiut, Egypt
[3] Department of Community Medicine, Assiut University, Assiut, Egypt
[4] Basic Medical Science Department, Faculty of Medicine, Aqaba Medical Sciences University, Aqaba, Jordan

neuropsychiatric condition affecting ~ 5% of stroke survivors [6].

Based on the Diagnostic and Statistical Manual of Mental Disorders-5th edition (DSM-5), PSP is categorized as a psychotic disorder due to another medical condition, specifically stroke. It is characterized by delusions and/or hallucinations, impaired reality testing, and a thorough exclusion of alternative factors, with particular emphasis on ruling out delirium [7]. The most common clinical presentations of PSP are delusional disorder, schizophrenia-like psychosis, and mood disorder with psychotic features [8].

The precise pathophysiological mechanisms underlying PSP remain incompletely elucidated, but it is considered multifactorial, involving neuroinflammation, neurodegeneration, neurotransmitter dysregulation, and structural and functional brain changes [9]. Psychosis arises from dysfunction in the subcortical basal ganglia–limbic system interaction, involving abnormal dopaminergic neurotransmission [10]. However, lesions in multiple brain regions are proposed as prerequisites for the clinical manifestation of PSP [11]. Cerebral atrophy, particularly in subcortical areas, may contribute to PSP progression [12]. Right hemispheric lesions, especially in the right temporo-parieto-occipital regions, are associated with increased PSP susceptibility, with symptom expression contingent upon the lesion location [12–14].

A correlation between positive psychotic symptoms, decreased cognitive inhibition, and increased left hemispheric activity following reduced right hemisphere functioning has been postulated [15]. Moreover, involvement of the superior longitudinal fasciculus and the right inferior frontal lobe increases the likelihood of PSP, potentially due to compromised anatomical connectivity and neuronal hyperactivity in the disconnected cortex [11].

The long-term prognosis for patients diagnosed with PSP typically presents a pessimistic perspective, and the underlying factors contributing to this outcome remain relatively ambiguous. Nevertheless, there is a suggestion that the poor prognosis and higher mortality rates found in individuals with PSP, similar to those with primary psychosis, may be influenced by adverse lifestyle choices and physical comorbidities, such as cardiovascular diseases [16]. PSP often goes undiagnosed, as comprehensive evaluations of this disorder are scarce, with the only published evidence being limited to a handful of case reports [14, 17–25]. There is a paucity of guidelines for diagnosing and managing PSP, indicating the need for further research in this area [8, 17, 26, 27]. Hence, the purpose of this study is to assess the prevalence and determinants of post-stroke psychosis (PSP), as well as to compare PSP and non-PSP patients in terms of improvement and daily living outcomes.

Methods

This study constituted nested case–control (NCC) research. It included a total of 2,624 patients who were recruited from the Neurology department at Aswan University Hospital between May 2017 and April 2022. These patients experienced acute cerebrovascular stroke, according to the WHO definition [28], within one week. Among them, 108 patients who met the inclusion and exclusion criteria and developed PSP were included in the study. Additionally, 119 patients who did not develop PSP were also included. The study included individuals who had experienced an acute stroke and exhibited behavioral alterations such as delusions and/or hallucinations, impaired capacity to perceive reality, and mood disorders with psychotic symptoms within 6 months of the stroke. Participants of any age and gender were eligible.

The study excluded individuals who met the following criteria: participants who had experienced a transient ischemic attack or stroke in conjunction with other primary brain lesions, such as tumors; participants who had unreliable sources of information or who refused to participate; individuals with known renal, hepatic, or pre-existing psychiatric disorders; those who were unable to communicate effectively, such as those with sensory aphasia or pre-existing neurocognitive impairment or dementia; and individuals who were currently taking medications that could impact mental functioning, such as psychotropic drugs.

The Diagnostic and Statistical Manual of Mental Disorders-5th Edition (DSM-5) [7] was used to diagnose psychiatric disorders, and the Structured Clinical Interview for DSM-5 Disorders—Clinician Version (SCID-5-CV) during the psychiatric interview [29] was used to confirm the diagnosis and exclude comorbidities.

The baseline assessment included a collection of data related to risk factors for stroke, which was self-reported or family-reported information. These risk variables encompassed sociodemographic characteristics, hypertension, diabetes mellitus, heart illnesses, smoking habits, family history of stroke, and the frequency of stroke recurrences. Also, during the screening and data collection process, information on participants' past history and family history of psychiatric disorders was collected. The data were received directly from the patient or their caregivers. During the admission process, all patients had a comprehensive neurological and general examination, which included measuring their body mass index (BMI). Patients with a BMI score of 30 kg/m^2 or higher were classified as having obesity [30].

Laboratory and imaging investigations were done, and they included a computed tomography (CT) scan (Siemens Spirit Dual Slice CT Scanner, Rs 54 Lakh, Germany) to validate the diagnosis of stroke. The patients

were categorized based on their clinical presentation and neuroimaging findings into two groups: ischemic/hemorrhagic stroke (including cerebral and subarachnoid hemorrhage) with specific localization of cerebral abnormalities. A lipogram was conducted on all patients following a fasting period of more than 14 h. In this investigation, hypercholesterolemia was operationally defined as blood values surpassing 239 mg/dl, while hypertriglyceridemia was defined as blood values exceeding 200 mg/dl [31]. Electrocardiography (ECG) and/or echocardiography were conducted to ascertain the presence of arrhythmia and/or ischemia. The specific equipment used for this purpose was the CON-TEC ECG100G type, manufactured in China. Electroencephalography (EEG) was conducted on individuals who were presented with seizure activity.

Assessment scales were applied for each participant and included the Barthel index (BI), which is an assessment of stroke severity that was conducted using the Barthel index (BI) [32, 33]. The BI categorizes stroke severity into three grades: extremely poor, indicating complete dependency (BI score < 60); poor, indicating aided independence (BI score 60- < 95); and good, indicating minimum or no disability (BI score ≥ 95). The Hamilton Depression Rating Scale (HDRS) [34] was used to assess depression, whereas those with HDRS scores exceeding seven were determined to be experiencing depression. The Mini-Mental State Examination (MMSE) [35] was used to assess the cognitive function. Individuals with MMSE scores of 23 or lower (≤ 21 for illiterates) were identified as having dementia.

The participants underwent systematic evaluation at two time points: (1) at admission/baseline, applying the inclusion and exclusion criteria for selecting eligible patients. And (2) at a 6-month follow-up after the stroke, to assess for the occurrence of PSP and to perform clinical and neurological evaluations. Psychiatric interviews and questionnaires were used to detect alterations in behavior, and the presence of delusions, or hallucinations. Additionally, clinical assessments were performed, including neurological examinations and evaluations of stroke severity using the Barthel index (BI) to assess the outcomes in all participants with cerebrovascular syndrome (CVS).

The sample size was calculated using G*Power 3 software [36]. To achieve a statistical power of 90% and an error probability of 0.05 in a two-tailed test, a minimum sample size of 206 stroke patients was estimated. This sample was divided into two groups, consisting of 103 patients with PSP and 103 patients without PSP. However, the final analytical sample consisted of 108 cases with PSP and 119 controls without PSP out of the total 2624 patients in the stroke initial screening pool. Additional eligible participants became available during the recruitment phase, resulting in a marginal increase in sample size beyond the minimum calculated (103 per group). We included all participants who met the eligibility criteria to enhance the statistical power and accuracy of our analyses. This discrepancy arose due to the naturally occurring prevalence of PSP in the stroke population that we examined, as demonstrated by the increase from 108 cases to 119 controls.

Statistical analysis in which the data were processed and analyzed using IBM-SPSS 21.0, a software developed by IBM-SPSS Inc. in Chicago, IL, USA. Descriptive statistics were calculated, encompassing measures such as means, standard deviations, and percentages. The Chi-square test and Fisher's exact test were used to assess the disparity in the distribution of frequencies across various groups. In addition, the independent *t*-test analysis was conducted to compare the means of binary data. The univariate analysis identified important variables, which were subsequently included in a multivariable logistic regression model. This model was used to examine the independent predictors of psychosis in patients with stroke, utilizing odds ratios (OR), 95% confidence intervals (CI), and *P*-values. A *P*-value is considered significant if it is equal to or less than 0.05.

Results

A total number of 2624 stroke patients were assessed for eligibility criteria; 179 of them were excluded because they did not meet the inclusion criteria, while 444 patients dropped out during the follow-up (Fig. 1). Among 2001 stroke patients included and were potential cases and controls, 108 patients (5.4%) developed psychosis. The control group, 119 stroke patients who did not develop PSP, were drawn at random from the risk set of all those who did not develop PSP by the time of the case's PSP diagnosis.

Patients with PSP had a significantly higher mean age (65.2 ± 22.6) compared to those without PSP (60.66 ± 13.8). There was a significant difference in the sex distribution between the two groups, with a higher proportion of males in the PSP group. A higher percentage of patients in the PSP group had less than or equal to 5 years of education. And smokers/ex-smokers compare to another group. No significant differences were observed for other risk factors like hypertension, diabetes, cholesterol levels, or obesity (Table 1).

Table 2 demonstrates compares various clinical and imaging findings between the studied groups. Patients with PSP had significantly higher rates of motor deficits (hemiplegia) (37%), sphincter affection (63%), post-stroke dementia (77.8%), seizures (25.9%), and extrapyramidal symptoms (14.8%) than the other group.

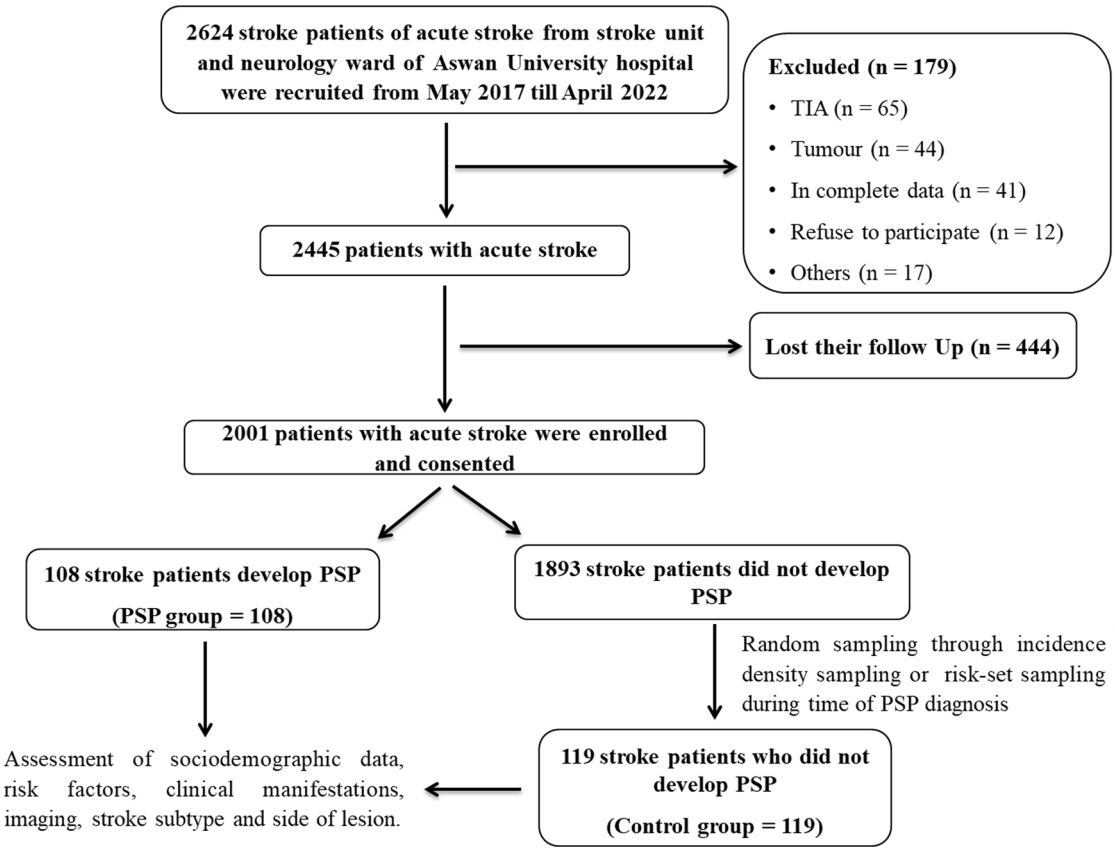

Fig. 1 Flowchart of study participants' selection

Regarding CT scans, patients with PSP had a significantly higher prevalence of small vessel lesions (7.4%) and brain atrophy (55.6%) compared to another group. Ischemic stroke had a higher proportion in the PSP group compared to the non-PSP group.

Patients with PSP had a significantly higher frequency of right-side lesion (63%) than the other group (52.1%). Furthermore, the PSP group had lower scores on MMSE for cognitive status (17.30 ± 3.1) compared to the non-PSP group (25.82 ± 5.3).

As regards the pattern of PSP, the majority (55.5%) had an unspecified psychosis, followed by delusional disorder (20.4%), schizophrenia-like disorder (14.8%), and mood with psychotic features (9.3%) (Table 3).

The multivariate regression model demonstrated that older age, male patients, lower education level (≤ 5 years), hemiplegia, sphincter affection, cortical lesion, brain atrophy, small vessel disease, ischemic stroke, post-stroke dementia, and seizure (Table 4).

Figures 2 illustrates a significantly higher percentage of excellent patients in the non-PSP group compared to those who had PSP regarding the observed improvement in the patient's condition.

Figure 3 demonstrates a significantly higher percentage of deteriorated patients in the PSP (46.6%) group compared to those who had no PSP (18.9%) regarding the Barthel index. Conversely, a higher percentage of improved patients in the non-PSP group compared to those who had PSP.

Discussion

Post-stroke psychosis (PSP) is a significant neuropsychiatric complication that can profoundly impact the prognosis and quality of life of stroke survivors. Despite its importance, PSP is often underdiagnosed and undertreated, and there is a paucity of global data on its prevalence and risk factors. The present study investigated the prevalence, determinants, and outcomes of post-stroke psychosis (PSP) among acute stroke patients in the Aswan region. The main findings of this study were determining the burden of PSP, highlighting its considerable prevalence of 5.4% among the cohort of 2624 acute stroke patients. Additionally, this study identified potential risk factors and determinants associated with the development of PSP. These findings underscore the urgent need to target screening, prevention, and management of PSP.

Table 1 Sociodemographic characteristics and risk factors of the studied stroke groups

	Without PSP (*n* = 119)	With PSP (*n* = 108)	*P*-value
Age/years	60.66 ± 13.8	65.19 ± 22.6	= 0.001*
Sex (male/female)	44/75	76/32	< 0.001**
Residence (rural/urban)	29/90	32/76	= 0.329**
Education			
≤ 5 years education	61 (51.3%)	72 (66.7%)	= 0.019**
> 5 years education	58 (48.73%)	36 (33.33%)	
Occupational status			
Working	35 (29.4%)	20 (18.5%)	= 0.056**
Un-working	84(70.6%)	88(81.5%)	
Marital status			
Married	85 (71.4%)	64 (59.3%)	= 0.044**
Single	34(28.6%)	44(40.7%)	
Risk factors			
Smoker/ex-smoker	23 (19.3%)	32 (29.6%)	= 0.049**
History of hypertension	70 (58.8%)	52 (48.1%)	= 0.107**
History of DM	46 (38.7%)	32 (29.6%)	= 0.153**
Triglycerides (mg/dl)	197.14 ± 10.2	155.32 ± 16.8	= 0.001*
Cholesterol (mg/dl)	213.77 ± 51.5	203.36 ± 45.6	= 0.109*
Obesity	25 (21%)	16 (14.8%)	= 0.226**
ECG changes	66 (55.5%)	48 (44.4%)	= 0.097**

PSP post-stroke psychosis, *DM* diabetes mellitus, *ECG* electrocardiography

* Independent *t*-test was used to compare the means among groups

** Chi-square analysis was used to compare the frequency among groups

Table 2 Clinical and imaging findings among the studied stroke groups at 6-month follow-up

Variable	Without PSP (*n* = 119)	With PSP (*n* = 108)	*P*-value*
Motor deficit (hemiplegic)	28 (23.5%)	40 (37%)	= 0.026*
Sphincter affection	29 (24.4%)	68 (63%)	< 0.001*
Post-stroke dementia	17 (14.3%)	84 (77.8%)	< 0.001*
Depression	36 (30.3%)	36 (33.3%)	= 0.618*
Seizures	10 (8.4%)	28 (25.9%)	= 0.001*
Extra-pyramidal symptoms	6 (5%)	16 (14.8%)	= 0.013*
CT findings			
- Cortical lesion	46 (38.7%)	48 (44.4%)	= 0.377
- Small vessel lesion	1 (0.8%)	8 (7.4%)	= 0.012**
- Brain atrophy	19 (16%)	60 (55.6%)	< 0.001
Stroke subtype			
Ischemic/hemorrhagic	100/19	104/4	= 0.002*
Side of lesion			= 0.026**
- Left	48 (40.3%)	28 (25.9%)	
- Right	62 (52.1%)	68 (63%)	
- Bilateral	9 (7.6%)	12 (11.1%)	
Number of stroke	1.17 ± 0.5	1.19 ± 0.6	= 0.816***
BI	74.66 ± 13.1	70.37 ± 12.7	= 0.290***
MMSE	25.82 ± 5.3	17.30 ± 3.1	< 0.001***

PSP post-stroke psychosis, *CT* computed tomography, *BI* Barthel index, *MMSE* Mini Mental-State Examination

* Chi-square analysis was used to compare the frequency among groups

** Fisher's exact test was used to compare the frequency among groups

*** Independent *t*-test was used to compare the means among groups

Table 3 Descriptive analysis of stroke patients with psychosis

Variable	Category	*n* = 108
Pattern of PSP	- Delusional disorder	22 (20.4%)
	- Schizophrenia like disorder	16 (14.8%)
	- Mood with psychotic features	10 (9.3%)
	- Unspecified psychosis	60 (55.5%)

PSP post-stroke psychosis

Recognizing and appropriately treating PSP is essential for optimizing the recovery and long-term outcomes of stroke survivors.

In this study, 5.4% (108/2624) of stroke patients initially screened developed PSP within 6 months post-stroke. These prevalence estimates closely align with the findings from a prior systematic review in 2018 (4.86%) [8], verifying that PSP is a relatively common neuropsychiatric consequence across diverse settings and suggesting that the prevalence is likely greater than previously assumed [8].

Several sociodemographic characteristics exhibited significant associations with PSP risk. In this study, patients with PSP had a higher mean age (65.2 years) compared to non-PSP controls (60.7 years). This finding is comparable to the age of (66.6 years) which was reported in the former meta-analytic study by Stangeland et al. in 2018 [8]. Advanced age is a likely risk factor for the development of PSP because of the increased possibility of associated brain atrophy and atherosclerosis that lead to disruption of neuronal networks.[8, 37]

In the present study, PSP was significantly more prevalent among males compared to females. Stangeland et al. in 2018 [8], reported that PSP is more prevalent in males than females. However, this gender distribution contradicts the broader stroke population, where females exhibit a higher prevalence of stroke [38]. Moreover, it has been shown that males are more susceptible to primary psychotic diseases, such as schizophrenia [39]. At the same time, females seem to be disproportionately affected by late-onset psychosis, which manifests after the age of 60 years [40]. The relationship between gender and the hazards associated with stroke is multifaceted, encompassing historical, neurological, and social risk factors [41]. It is anticipated that a similarly complicated scenario might

Table 4 Predictors of PSP among stroke patients using logistic regression model

Variable	Multivariate	
	OR (95% CI)	*P*-value
Age/years	1.015 (1.002–1.046)	= 0.017
Sex (male)	2.054 (1.497–5.028)	< 0.001
≤ 5 years education	3.380 (1.894–5.427)	= 0.009
Hemiplegic	1.698 (1.072–3.524)	= 0.034
Sphincter affection	1.347 (1.045–3.587)	= 0.011
CT findings		
- Normal	1	= 0.001
- Cortical lesion	2.124 (1.031–5.052)	= 0.041
- Brain atrophy	1.924 (1.041–4.002)	= 0.033
- Small vessel lesion	2.254 (1.058–4.121)	= 0.042
Ischemic stroke	3.158 (1.127–6.274)	= 0.011
Post-stroke dementia	9.214 (3.664–24.512)	< 0.001
Seizures	4.689 (1.429–7.958)	= 0.017

OR odds ratio, *CI* confidence interval, *PSP* post-stroke psychosis, *CT* computed tomography

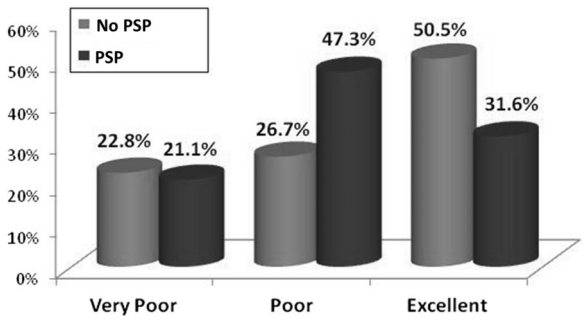

Fig. 2 Distribution of the sample according to improvement status

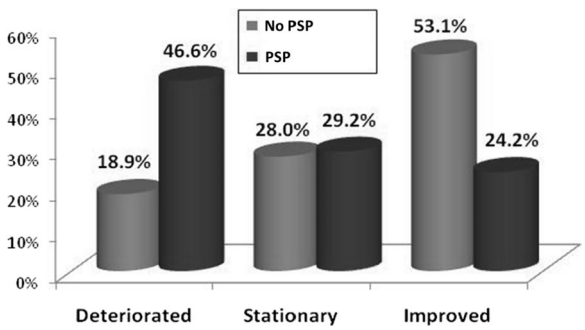

Fig. 3 Distribution of the sample according to improvement status (via Barthel index after 6 months)

emerge in the context of PSP. Sensory deprivation is one of the predisposing factors of psychosis, and social isolation or limited activity negatively impacts general health, affecting the self-confidence of the patients during periods of difficulty and stress [42]. These demographic risk factors suggest potential sociocultural influences and disparities that may contribute to PSP vulnerability and warrant further exploration from a social epidemiological perspective.

In the current study, we observed a higher incidence of PSP among single individuals in the PSP group (40.7%) compared to the non-PSP group (28.6%), suggesting that being single with a lack of family support may be a risk factor for PSP. Also, PSP was found to be significantly more prevalent among patients with ≤ 5 years of education. Educational attainment may cultivate enhanced self-adjusting abilities [43], which play a role in accommodating the change of PSP. Moreover, we detected a significantly higher prevalence of smoking among patients with PSP (29.6%) compared to those without (19.3%). Smoking is an independent risk factor for atherosclerosis and small vessel disease that may widely disrupt neuronal networks.

A previous study conducted a cohort analysis to examine the occurrence of psychotic symptoms among people who had cardiac surgery, and it identified stroke as a significant and independent risk factor for the development of psychotic symptoms [44]. Also, PSP risk factors were consistent with general stroke risks [45].

In this study, there were characteristic clinical and neurological findings in the PSP group. The PSP group demonstrated significantly higher rates of motor deficits like hemiplegia (37%), sphincter disturbances (63%), post-stroke dementia (77.8%), seizures (25.9%), and extrapyramidal symptoms (14.8%) relative to non-PSP stroke survivors. These findings underscore the broader neurological and cognitive sequelae associated with PSP, beyond the acute stroke event itself. In contrast, Stangeland et al. in 2018 in their meta-analysis found that the most common neurological signs accompanying post-stroke psychosis were left-sided weakness, headache, slurred speech, left-sided neglect, decreased or impaired left-sided vision, left-sided facial weakness, and confusion, which are common stroke symptoms indicating right hemisphere lesion [46]. However, a significant minority had 'silent strokes' with subtle or undetected neurological signs, suggesting stroke may go undetected for a considerable time. The development of psychosis, associated with treatment delay, [47] might affect the chances of later stroke detection.

According to previous literature, evidence suggests that seizures resulting from lesions are associated with a higher likelihood of developing PSP [48]. This finding aligns with the observations by Khan and colleagues, who reported an increased incidence of PSP among patients with post-stroke seizures [49]. Consequently, our study

also indicates that post-stroke seizure can be a predictive factor for PSP.

This study found that post-stroke dementia was more frequently observed in participants with PSP, indicating a significant association between post-stroke psychosis and cognitive impairment. However, the precise nature of this association remains unclear, as the interaction could be bidirectional, or the two conditions might manifest independently. Rasquin et al. provided evidence of a high prevalence of significant cognitive abnormalities among those exhibiting psychotic symptoms [50]. Furthermore, another study highlighted a correlation between the lesion location and the presence of both psychotic symptoms and cognitive impairments [51]. These symptoms are commonly observed in stroke cases and may be considered reliable indicators of PSP [52]. In general, the presence of post-stroke dementia could potentially confound the interpretation of our findings on PSP, as dementia itself is a risk factor for psychosis. In future studies, it would be valuable to stratify the analyses based on the presence or absence of post-stroke dementia and explore potential differences in the manifestation and risk factors of post-stroke psychosis between these subgroups.

In this study, patients with PSP exhibited distinct neuroimaging profiles, with a higher prevalence of small vessel lesions, cortical lesions, and brain atrophy compared to non-PSP controls. The observed phenomenon can be related to the interruption of intracerebral circuits, the functional disconnection of the cortical region, and the impact of inflammatory mediators resulting from vascular injury or systemic consequences [11, 12, 53–55].

Our study revealed a higher prevalence of PSP among patients with ischemic strokes than those with hemorrhagic strokes. This contrasts with the findings of Shiber et al., who concluded that stroke type does not serve as a predictive factor for subsequent psychosis. The observed phenomenon can be attributed to cerebral infarction, resulting in a more extensive and severe impairment of brain tissue [56].

The majority of patients (63%) in the PSP group were found to have right hemisphere lesions which aligns with extensive empirical research indicating that right hemisphere lesions are linked to various perceptual and belief issues [25]. The preferential involvement of the right cerebral hemisphere aligns with previous literature implicating its different regions and their associated neural networks in the neuropathogenesis of PSP [11, 12, 53–55]. However, it is worth bearing in mind that left hemisphere strokes are more likely to result in language and communication problems, which may impede the assessment of psychosis, and therefore these patients may be under-represented in the literature [57].

Regarding clinical phenotypes of PSP, the majority of PSP cases (55.5%) presented with an unspecified psychosis, followed by delusional disorder (20.4%), schizophrenia-like disorder (14.8%), and mood disorder with psychotic features (9.3%). The preponderance of delusional disorder in our study aligns with prior systematic review findings, where circumscribed delusional presentations outnumber schizophrenia-spectrum and mood psychoses [8]. In contrast, the 'non-organic' delusional disorder has a relatively low lifetime prevalence in the general population [58, 59]. This pattern potentially reflects the more localized lesions in PSP compared to the distributed neurobiological changes underlying primary psychotic disorders [58, 59].

In this study, multivariate logistic regression identified older age, male sex, lower education level (≤ 5 years), hemiplegia, sphincter affection, cortical lesions, brain atrophy, small vessel disease, ischemic stroke, post-stroke dementia, and seizures as independent predictors of PSP development. Many of these risk factors corroborate findings from the previous systematic review [8], including right hemispheric lesion location, vascular risk factors predisposing to small vessel disease, and cognitive/functional sequelae of cerebrovascular disease [12, 55, 60].

This study conducted a prospective assessment at 6 months and revealed poorer functional outcomes among PSP patients compared to non-PSP stroke survivors. A significantly higher proportion of PSP cases exhibited deterioration on the Barthel index, an established measure of disability and dependence in activities of daily living. Conversely, a lower percentage of PSP patients demonstrated improvement in functional status. Our findings supported the statement that the long-term outcomes of PSP are generally poor [8], suggesting that patients with PSP may have more incredible difficulty managing the effects of stroke and are more likely to rely on assistance daily than other stroke survivors. These findings substantiate the detrimental impact of PSP on rehabilitation trajectory and long-term independence, in line with conclusions from the prior systematic review [6, 61]. Putative mechanisms include compounded cognitive and neuropsychiatric impairments hindering engagement with therapeutic activities, suboptimal management due to diagnostic overshadowing or inappropriate treatment provision, and potential adverse effects of psychotropic medications used off-label in this population [8].

Several limitations of this study included: firstly, the single-center study design and relatively small sample size may limit the generalizability of the results. Secondly, the lack of uniform diagnostic criteria, specific assessment instruments, and reliable markers, such as

biochemical markers, poses a significant challenge in the precise identification of post-stroke psychosis (PSP). Thirdly, due to the constraints of the healthcare system, it was not feasible to conduct serial psychological evaluations of patients to determine the accurate onset of psychosis following stroke events. Fourthly, the paucity of prior comparable research in this domain hinders the ability to contextualize and validate the current findings adequately. Additionally, age and sex differences across study groups may introduce confounding variables and limit generalizability. Finally, this study did not exclude patients developing post-stroke dementia during follow-up, which could potentially confound our findings regarding PSP. Moreover, this study did not explore the temporal relationship between psychosis and dementia onset. Future research should determine the sequence of these conditions' onset, and examine outcomes, treatment effects, and potential for improvement in patients with both PSP and cognitive impairment.

Recommendation and future directions

Given the identified risk factors and potential determinants of PSP, we recommend standardized screening protocols to identify high-risk patients early and address modifiable lifestyle factors associated with PSP. Providing caregiver support and educating patients and caregivers about PSP risk factors, symptoms, and consequences is crucial. Comprehensive care should be delivered by a multidisciplinary team of neurologists, psychiatrists, rehabilitation experts, and social workers, prioritizing both functional recovery and psychosocial support. Further multicenter studies are essential to explore PSP's underlying mechanisms, evaluate potential therapies, and develop an algorithmic diagnostic approach for early detection. Such studies should also investigate long-term psychological outcomes and develop new neuroimaging techniques and biomarkers for early detection and monitoring.

Conclusions

The incidence of PSP was 5.4% 6 months following a stroke. Male gender, smoking, ischemic infarction with right hemispheric lesion or cortical lesion, small vessel disease or brain atrophy on neuroimaging, extrapyramidal manifestations or sphincter disruption or convulsions or cognitive impairment were associated with an increased risk for developing PSP. Assessing psychological status early in the progression of a stroke and identifying risk factors and predictors of PSP are crucial. This could aid in the prevention of further deterioration and improve psychological health through effective intervention.

Abbreviations

BI	Barthel index
CT	Computed tomography
ECG	Echocardiography
EEG	Electroencephalography
HDRS	Hamilton Depression Rating Scale
MMSE	Mini-Mental State Examination
PSP	Post-stroke psychosis
WHO	World Health Organization

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Author contributions

BMA; study concept, design, literature search, clinical studies, manuscript preparation, editing and review. GKA; literature search, clinical studies, editing and review. AKI; methodological design, data analysis, statistical analysis, editing and review. MAA; study concept, design, editing and review. NAH; literature search, data analysis, manuscript preparation, editing, and review. All authors have read and approved the manuscript.

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Availability of data and materials

The data set of this work is available and uploaded with this article.

Declarations

Ethics approval and consent to participate

The study received approval from the Institutional Review Board (IRB) of the Medical Faculty at Aswan University prior to its commencement (IRB No. Asw-377-7-19). The study adhered to the guidelines set forth in the World Medical Association Declaration of Helsinki. Furthermore, all participants or their careers were provided with a formal consent form. The informed consent document provided clear information regarding the study's objectives and participants' autonomy to voluntarily participate or withdraw from the study without any kind of coercion or obligation. In addition, the confidentiality and anonymity of the participants were ensured through the allocation of unique code numbers solely for the purpose of analysis. The study did not use any form of incentives or prizes as a means of motivating the subjects.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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