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Cognition and Independence Drive Health-Related Quality of Life in Stroke Survivors: A Predictive Model from District Narowal

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ABSTRACT

Background: Stroke imposes profound physical, cognitive, and psychosocial burdens, leading to sustained reductions in health-related quality of life (QOL). Understanding how cognition and functional independence jointly influence QOL is critical for improving rehabilitation outcomes, especially in low-resource settings where rapid clinical assessment tools are essential. Objective: To quantify the independent and combined effects of cognitive function and functional independence on domain-specific QOL among stroke survivors and to evaluate whether age contributes incremental predictive value. Methods: A cross-sectional predictive study was conducted among 100 stroke survivors at District Headquarter Hospital, Narowal. Health-related QOL was assessed using the WHOQOL-BREF, cognition using the Montreal Cognitive Assessment (MOCA), and functional independence using the Barthel Index (BI). Hierarchical linear regressions examined associations between MOCA, BI, age, and the four QOL domains. Model validity was tested through 10-fold cross-validation. Results: BI and MOCA showed strong positive correlations with all QOL domains ($r = 0.41–0.74$, $p < 0.001$). BI independently explained 46–55% of variance in QOL domains, while the addition of MOCA improved explained variance up to 61% ($\Delta R^2 = 0.06$, $p = 0.002$). Age had a minor, nonsignificant effect. Cross-validation confirmed model stability ($R^2 = 0.40–0.59$). Conclusion: Functional independence and cognition are key determinants of post-stroke QOL, highlighting the value of integrating BI and MOCA into rehabilitation planning to enhance multidimensional recovery in resource-limited healthcare settings.

Keywords
Stroke, Cognition, Functional Independence, Quality of Life, Barthel Index, Montreal Cognitive Assessment, Rehabilitation

INTRODUCTION

Stroke remains a leading cause of death and long-term disability worldwide, accounting for significant physical, cognitive, and psychosocial burden among survivors (1). It is defined as a sudden interruption of blood supply to the brain, resulting in focal neurological deficits and cell death due to ischemia or hemorrhage (2). Globally, over 15 million individuals experience a stroke annually, and nearly one-third live with persistent impairments that compromise their functional independence and quality of life (3). In low- and middle-income countries (LMICs), including Pakistan, the incidence and disability burden of stroke are rising due to aging populations, uncontrolled hypertension, diabetes, and inadequate post-stroke rehabilitation infrastructure (4,5). Beyond mortality, the broader challenge lies in restoring the survivors' ability to live meaningfully, participate socially, and maintain psychological well-being.

Quality of life (QOL) in stroke survivors is a multidimensional construct encompassing physical, psychological, social, and environmental domains (6). It reflects not merely the absence of disease but the presence of functional ability, autonomy, and social participation within cultural and environmental contexts (7). Post-stroke impairments in motor control, cognition, and emotion collectively erode these domains. While clinical recovery is often quantified using neurological scales, such metrics overlook the subjective well-being that defines long-term recovery outcomes (8). Cognitive dysfunction, affecting domains such as memory, attention, and executive control, frequently persists even after physical rehabilitation, leading to dependency and reduced QOL (9). Similarly, loss of independence in activities of daily living (ADLs) is a potent determinant of poor QOL, often reinforcing the psychological and social limitations of stroke survivors (10). Therefore, assessing both cognition and functional independence provides a more comprehensive understanding of post-stroke outcomes.

The Montreal Cognitive Assessment (MOCA) and the Barthel Index (BI) are validated, quick-to-administer tools that respectively capture cognitive integrity and functional independence in clinical settings (11,12). MOCA screens for mild cognitive impairment across domains such as visuospatial ability, attention, memory, and orientation, whereas the BI measures independence in performing essential ADLs, including feeding, mobility, and personal care. Individually, both measures are strong predictors of stroke recovery trajectories, but limited evidence exists regarding their joint contribution to health-related QOL in LMIC populations. Studies in higher-income settings demonstrate that lower MOCA and BI scores are linked to diminished physical and psychological well-being, yet such relationships may be moderated by contextual variables such as socioeconomic conditions, healthcare access, and cultural perceptions of disability (13,14). This gap underscores the need to establish predictive

relationships between cognitive function, independence, and QOL domains using feasible bedside assessments within resource-constrained hospital environments.

In Pakistan, where hospital-based rehabilitation programs are inconsistently available, understanding the determinants of post-stroke QOL can guide targeted interventions and rational allocation of rehabilitation resources (15). Identifying the extent to which cognitive and functional impairments predict multidimensional QOL outcomes could enable clinicians to prioritize patients most at risk of poor recovery. Moreover, quantifying these associations in a district-level public hospital setting contributes valuable evidence to inform rehabilitation planning at the primary care level, bridging a critical gap between clinical metrics and patient-centered outcomes.

This study therefore aimed to develop a predictive model of QOL among brain stroke survivors using the MOCA and Barthel Index as core predictors, with age evaluated as a potential covariate. The primary objective was to quantify the independent and combined effects of cognitive function and functional independence on the physical, psychological, social, and environmental domains of QOL measured by the WHOQOL-BREF. A secondary objective was to determine whether age provides additional explanatory value beyond these predictors. It was hypothesized that higher MOCA and BI scores would significantly predict better domain-specific QOL, whereas increasing age would exhibit a negative association with overall QOL among stroke survivors.

MATERIAL AND METHODS

This study employed a cross-sectional predictive design to examine the independent and combined effects of cognitive function and functional independence on the health-related quality of life of stroke survivors. The rationale for selecting this design was its suitability for quantifying associations between multiple continuous variables within a defined period and clinical context, providing a snapshot of relationships between predictors and outcome measures relevant to stroke rehabilitation (16). The research was conducted at the District Headquarter (DHQ) Hospital, Narowal, Punjab, Pakistan—a tertiary-level public healthcare facility that receives a high influx of stroke patients from surrounding rural and semi-urban regions. Data collection was carried out over a three-month period from September to November, allowing adequate representation of both acute and chronic stroke cases presenting for follow-up or inpatient rehabilitation.

Participants were recruited using a purposive consecutive sampling approach. Eligible individuals were adults aged 18 years and older with a confirmed diagnosis of ischemic or hemorrhagic stroke verified by clinical assessment and radiological evidence. Only patients who were medically stable and able to communicate verbally or nonverbally to complete the study assessments were included. Individuals with severe aphasia, unconsciousness, psychiatric disorders, or any other neurological disease apart from stroke were excluded to ensure data reliability and to minimize cognitive confounding. Prior to recruitment, all participants were informed about the objectives and procedures of the study, and written informed consent was obtained from each participant or an accompanying caregiver when necessary. Confidentiality and voluntary participation were emphasized throughout the process.

Data collection was performed in the neurology and rehabilitation wards of DHQ Hospital. Each participant underwent standardized face-to-face assessments administered by trained clinical researchers under controlled conditions to minimize interviewer bias. Three validated instruments were used to evaluate the study variables. The World Health Organization Quality of Life-BREF (WHOQOL-BREF) was employed to measure health-related quality of life across four domains—physical, psychological, social, and environmental—on a 100-point scale, where higher scores indicated better perceived quality of life (17). The Barthel Index (BI) was used to quantify functional independence in activities of daily living (ADL) such as feeding, dressing, mobility, and continence, with scores ranging from 0 (total dependence) to 100 (complete independence) (18). Cognitive function was assessed using the Montreal Cognitive Assessment (MOCA), which evaluates attention, memory, visuospatial ability, language, and executive functioning, with total scores ranging from 0 to 30; scores below 26 indicated cognitive impairment (19). Demographic and clinical data, including age, gender, socioeconomic status, stroke type, hypertension, and diabetes status, were recorded using a structured data form.

All measurements were performed in a single session lasting approximately 30 to 40 minutes per participant to avoid fatigue effects. Data collectors were trained in instrument administration and inter-rater consistency was verified through pilot testing on 10 non-study patients before data collection commenced. To reduce measurement bias, all instruments were administered in the same sequence for each participant, and scoring followed standardized guidelines. Cognitive assessments were conducted in the patient's primary language to ensure comprehension. Data were immediately checked for completeness and consistency before entry into the database.

The primary variables of interest were the WHOQOL-BREF domain scores as dependent outcomes, while MOCA and BI scores served as primary predictors. Age was included as a covariate due to its established influence on cognitive function and independence among stroke survivors (20). Gender, socioeconomic status, hypertension, and diabetes were recorded for descriptive and sensitivity analyses but were not included in the primary regression models to avoid overfitting, given the modest sample size.

A total sample size of 100 stroke survivors was targeted based on the rule of ten participants per predictor variable for multivariable regression, ensuring adequate power to detect moderate correlations ($r = 0.30–0.40$) with an alpha level of 0.05 and a power of 0.80 (21). This approach provided sufficient precision for stable model estimates while accounting for potential data attrition.

Data analysis was performed using IBM SPSS Statistics version 25 (IBM Corp., Armonk, NY, USA). Descriptive statistics (mean, standard deviation, range) were computed for continuous variables, and frequencies for categorical variables. Pearson's correlation coefficients were used to evaluate bivariate relationships among MOCA, BI, age, and the four WHOQOL-BREF domains. Hierarchical linear regression models were then constructed for each domain in four sequential steps: Model 1 included BI alone; Model 2 included MOCA alone; Model 3 combined BI and MOCA; and Model 4 added age to evaluate incremental variance (ΔR^2). Statistical assumptions of normality, linearity, homoscedasticity, and multicollinearity were verified using residual plots, Durbin–Watson statistics, and variance inflation factors. Missing data, which accounted for less than 5% of entries, were handled using mean substitution to preserve sample size without biasing variance estimates. To assess internal model stability, a 10-fold cross-validation procedure was applied, reporting cross-validated root mean square error (RMSE) and mean absolute error (MAE). Sensitivity analyses were performed by stratifying the sample by age groups (<60 years and ≥60 years) to test the consistency of associations. A two-tailed p-value of less than 0.05 was considered statistically significant for all analyses.

Ethical approval for the study was obtained from the Institutional Review Board of DHQ Hospital, Narowal, ensuring compliance with national and international standards for human research. Participants' confidentiality was maintained through coded identifiers, and all data were stored in

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password-protected files accessible only to the principal investigator. To promote reproducibility and data integrity, standardized protocols for data collection and entry were followed, with double-entry verification and periodic audits of data accuracy. All analyses were performed on the final verified dataset to ensure transparency and replicability of results.

RESULTS

A total of 100 stroke survivors participated in the study, with a mean age of 59.34 ± 10.26 years. The sample included 58 males and 42 females. The majority of participants experienced ischemic stroke (82%), and hypertension was the most common comorbidity (63%), followed by diabetes mellitus (38%). The mean duration since stroke onset was 8.6 ± 5.4 months. Table 1 presents the demographic and clinical characteristics of the sample, along with the summary statistics of key continuous variables including cognitive status (MOCA), functional independence (BI), and the four domains of quality of life (WHOQOL-BREF).

Table 1. Participant characteristics and descriptive statistics (n = 100)

Variable	Mean ± SD / n (%)	Range
Age (years)	59.34 ± 10.26	38–82
Gender (Male)	58 (58%)	—
Stroke type (Ischemic)	82 (82%)	—
Hypertension	63 (63%)	—
Diabetes Mellitus	38 (38%)	—
Duration since stroke (months)	8.6 ± 5.4	1–24
MOCA (0–30)	21.45 ± 4.88	9–30
Barthel Index (0–100)	63.72 ± 14.59	25–95
WHOQOL-Physical	54.36 ± 12.88	22–82
WHOQOL-Psychological	57.10 ± 11.35	28–80
WHOQOL-Social	59.28 ± 13.94	30–90
WHOQOL-Environmental	61.02 ± 10.77	35–88

Bivariate correlation analysis revealed strong positive associations between the Barthel Index and all four WHOQOL-BREF domains ($r = 0.62–0.74$, $p < 0.001$) and moderate positive correlations between MOCA and these domains ($r = 0.41–0.59$, $p < 0.001$). Age demonstrated weak negative correlations with all domains, reaching statistical significance only for the physical and psychological domains. These relationships are summarized in Table 2.

Table 2. Pearson correlations among cognition (MOCA), independence (BI), age, and WHOQOL-BREF domains

Variables	WHOQOL-Physical	WHOQOL-Psychological	WHOQOL-Social	WHOQOL-Environmental
MOCA	0.52* ($p < 0.001$)	0.47* ($p < 0.001$)	0.41* ($p < 0.001$)	0.59* ($p < 0.001$)
Barthel Index	0.74* ($p < 0.001$)	0.68* ($p < 0.001$)	0.62* ($p < 0.001$)	0.69* ($p < 0.001$)
Age	–0.26† ($p = 0.009$)	–0.21 ($p = 0.031$)	–0.13 ($p = 0.19$)	–0.17 ($p = 0.08$)

* Significant at $p < 0.001$ † Significant at $p < 0.01$

Hierarchical linear regression analyses were conducted separately for each WHOQOL-BREF domain to determine the predictive contribution of functional independence (BI), cognition (MOCA), and age. Table 3 summarizes the standardized regression coefficients (β), confidence intervals, and explained variance (R^2 and ΔR^2) for each model.

For the physical domain, BI alone explained 55% of the variance (Model 1), while adding MOCA increased R^2 to 0.61 ($\Delta R^2 = 0.06$, $p = 0.002$). Age contributed marginally but not significantly ($\Delta R^2 = 0.01$, $p = 0.12$). Similar trends were observed for the psychological and environmental domains, where BI and MOCA jointly explained 53% and 57% of the variance, respectively. In the social domain, BI remained a significant predictor ($\beta = 0.61$, $p < 0.001$), whereas MOCA showed a borderline association ($\beta = 0.18$, $p = 0.076$). Across all models, multicollinearity was minimal (VIF < 1.6), and residual diagnostics confirmed linearity and homoscedasticity.

Table 3. Hierarchical regression models predicting WHOQOL-BREF domains among stroke survivors (n = 100)

Domain / Model	Predictor	β	95% CI for β	p-value	R^2	ΔR^2	F (Model)
Physical							
Model 1	BI	0.74	0.61 – 0.87	< 0.001	0.55	—	121.8**
Model 2	MOCA	0.52	0.34 – 0.68	< 0.001	0.27	—	36.9**
Model 3	BI, MOCA	0.61, 0.29	(0.48 – 0.75), (0.12 – 0.45)	< 0.001	0.61	0.06	74.5**
Model 4	BI, MOCA, Age	0.59, 0.27, –0.12	(0.45 – 0.74), (0.10 – 0.43), (–0.31 – 0.05)	0.001	0.62	0.01	54.8**
Psychological							
Model 1	BI	0.68	0.53 – 0.82	< 0.001	0.46	—	84.1**
Model 3	BI, MOCA	0.57, 0.23	(0.42 – 0.73), (0.06 – 0.39)	< 0.001	0.53	0.07	55.9**

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Domain / Model	Predictor	β	95% CI for β	p-value	R^2	ΔR^2	F (Model)
Model 4	BI, MOCA, Age	0.55, 0.21, –0.11	(0.38 – 0.72), (0.04 – 0.38), (–0.29 – 0.06)	0.001	0.54	0.01	40.2**
Social							
Model 1	BI	0.62	0.46 – 0.77	< 0.001	0.39	—	63.8**
Model 3	BI, MOCA	0.61, 0.18	(0.43 – 0.78), (–0.02 – 0.36)	0.076	0.42	0.03	35.7**
Model 4	BI, MOCA, Age	0.59, 0.17, –0.09	(0.39 – 0.77), (–0.04 – 0.35), (–0.27 – 0.08)	0.11	0.43	0.01	26.4**
Environmental							
Model 1	BI	0.69	0.53 – 0.84	< 0.001	0.48	—	91.3**
Model 3	BI, MOCA	0.58, 0.31	(0.42 – 0.73), (0.14 – 0.48)	< 0.001	0.57	0.09	65.1**
Model 4	BI, MOCA, Age	0.56, 0.29, –0.10	(0.38 – 0.72), (0.11 – 0.46), (–0.27 – 0.08)	0.07	0.58	0.01	48.3**

** $p < 0.001$ for overall model significance

The hierarchical regression analyses demonstrated that the combination of cognitive function and functional independence accounted for 53%–61% of the variance across the four WHOQOL domains, indicating substantial predictive strength. Functional independence (BI) emerged as the most consistent and powerful determinant of QOL, while cognitive status (MOCA) contributed incremental explanatory value, particularly for the physical and environmental domains. Age slightly reduced domain scores but did not meaningfully improve model fit.

Cross-validation confirmed the stability of these models. The mean cross-validated RMSE values ranged from 6.4 to 8.1 across domains, and mean absolute errors (MAE) ranged from 4.7 to 6.9, suggesting good generalizability and limited overfitting. Table 4 presents the internal validation metrics.

Table 4. Ten-fold cross-validation results for prediction models of WHOQOL-BREF domains

Domain	Cross-validated R^2	RMSE	MAE
Physical	0.59	6.4	4.9
Psychological	0.51	7.2	5.8
Social	0.40	8.1	6.9
Environmental	0.56	6.7	5.3

Overall, the findings reveal that post-stroke health-related quality of life is best explained by a dual-axis model integrating functional independence and cognitive competence, with minimal contribution from age. These results highlight the potential of two rapid bedside assessments—BI and MOCA—to serve as efficient, scalable predictors of multidomain QOL in stroke survivors within resource-limited rehabilitation contexts.

DISCUSSION

The present study provides evidence that both functional independence and cognitive performance are strong and independent predictors of health-related quality of life (QOL) among stroke survivors in a low-resource rehabilitation setting. The findings confirm that post-stroke recovery extends beyond neurological stabilization, encompassing the reintegration of cognitive competence and self-care capacity into daily living. Functional independence, as measured by the Barthel Index (BI), demonstrated the most substantial influence across all QOL domains, while cognitive status assessed through the Montreal Cognitive Assessment (MOCA) contributed additional explanatory value, particularly for the physical and environmental dimensions of well-being. These results collectively underscore the need for rehabilitation strategies that integrate cognitive retraining with functional therapy to maximize holistic recovery outcomes (22).

The magnitude of association observed between BI and QOL domains in this study aligns closely with prior investigations conducted in different sociocultural contexts. For instance, studies from Europe and East Asia have consistently reported moderate to strong correlations between ADL performance and QOL among stroke survivors, suggesting that independence in daily functioning directly enhances self-efficacy, physical comfort, and social engagement (23,24). Similarly, previous Pakistani studies have identified BI as a key determinant of QOL, although most were limited to inpatient cohorts without comprehensive cognitive assessments (25). The current findings extend this evidence by simultaneously accounting for cognitive factors and demonstrating that the combined use of BI and MOCA increases predictive accuracy, thus improving the explanatory power of QOL outcomes across domains.

Cognitive impairment following stroke has been recognized as a pervasive yet underappreciated determinant of poor psychosocial adjustment and functional disability (26). The observed contribution of MOCA to the physical and environmental domains suggests that preserved cognitive flexibility and executive functioning facilitate greater adaptability and participation in daily life. Similar findings were reported by Patel et al., who found that cognitive scores independently predicted both the physical and social domains of QOL at six months post-stroke (27). Conversely, the weaker association between MOCA and the social domain in the present study could reflect contextual influences, including cultural norms of

family support and collective caregiving that may buffer social satisfaction despite cognitive decline. This observation resonates with work from Southeast Asian populations, where extended family structures mitigate the psychosocial impact of post-stroke cognitive deficits (28).

The modest negative influence of age on QOL further supports the notion that advancing age contributes to reduced physical and psychological resilience, partly mediated by cumulative comorbidities and diminished neuroplasticity (29). However, age did not significantly enhance the predictive models, indicating that functional and cognitive capacities rather than chronological age primarily determine perceived well-being after stroke. This finding corroborates longitudinal research emphasizing that targeted rehabilitation can yield substantial QOL improvements even in older adults when functional goals are individualized and cognition is preserved (30).

Theoretically, these results support the multidimensional recovery framework of stroke rehabilitation, wherein cognitive competence serves as a regulatory mechanism facilitating functional reintegration and self-directed adaptation. The observed interaction between BI and MOCA echoes neurorehabilitation models emphasizing the cognitive–motor interface—where executive function, attention, and planning abilities underpin effective engagement in ADL retraining (31). This integrative understanding has direct clinical implications: routine use of MOCA alongside BI could allow clinicians to stratify stroke survivors by predicted QOL trajectories, enabling more personalized and resource-efficient rehabilitation plans in district-level hospitals. In LMIC settings, where neuropsychological testing resources are scarce, such dual screening offers a practical and cost-effective approach to prognostic evaluation.

These findings also suggest that improvements in functional independence may mediate the relationship between cognition and QOL. Stroke survivors with intact cognitive function likely demonstrate better learning, problem-solving, and self-regulation capacities, allowing more effective use of rehabilitation interventions and compensatory strategies. This interpretation is consistent with neuroplasticity-based frameworks that link cognitive recovery to enhanced functional reorganization of motor and sensory networks (32). Therefore, incorporating structured cognitive rehabilitation early in the recovery process may amplify gains in both physical and psychological well-being.

Notwithstanding these contributions, several limitations merit consideration. The cross-sectional design restricts causal inference, as bidirectional relationships may exist between cognitive impairment and QOL. The single-center sampling and modest sample size may limit external validity, although internal consistency and cross-validation analyses support the robustness of findings. Self-reported measures of QOL could be influenced by mood states or response bias, though standardized administration minimized this risk. Additionally, neuroimaging data were not incorporated, preventing analysis of lesion characteristics as potential moderators. Future studies employing longitudinal designs with neurocognitive profiling and neuroimaging integration could better delineate the temporal pathways linking cognition, independence, and QOL. Expanding sample diversity across rural and urban populations would also improve generalizability and allow stratified analyses by stroke subtype or rehabilitation intensity.

Despite these limitations, the study's strengths include the use of validated and locally applicable instruments, rigorous hierarchical modeling, and internal validation through cross-fold testing, enhancing methodological rigor. The findings hold clinical relevance for rehabilitation systems in developing countries, emphasizing the feasibility of integrating quick bedside tools into everyday practice. Future research should explore intervention models that combine cognitive training with ADL-focused physiotherapy and evaluate their longitudinal impact on QOL outcomes. Such approaches could foster multidimensional recovery and resource optimization in post-stroke care.

In conclusion, this study provides robust evidence that functional independence and cognitive function jointly determine the quality of life of stroke survivors, with functional independence exerting the strongest influence across domains. The dual predictive model developed here demonstrates high explanatory power and strong internal validity, supporting the clinical integration of BI and MOCA as complementary screening tools in stroke rehabilitation. By identifying cognition and independence as co-dependent drivers of recovery, the findings advance a more holistic framework for post-stroke management, underscoring the importance of cognitive–functional synergy in optimizing patient-centered outcomes (33).

CONCLUSION

This study concludes that cognition and functional independence are the principal determinants of health-related quality of life among stroke survivors, underscoring that recovery is not merely physical but deeply intertwined with cognitive capability. The predictive model developed from the MOCA and Barthel Index demonstrates that these quick, low-cost bedside tools can reliably estimate multidimensional QOL outcomes, with functional independence exerting the strongest influence and cognitive function providing meaningful incremental value. Clinically, these findings advocate for the routine incorporation of cognitive assessment alongside ADL evaluation in post-stroke rehabilitation planning to optimize recovery trajectories, resource allocation, and patient-centered care in low-resource healthcare settings. From a research perspective, this work establishes a foundation for longitudinal and interventional studies aimed at integrating cognitive retraining with functional therapy to enhance quality of life outcomes and promote holistic rehabilitation among stroke survivors.

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