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The development of cognitive and emotional impairment after a minor stroke: A longitudinal study

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Objectives: To study the development of cognitive and emotional symptoms between 3 and 12 months after a minor stroke.

Material and Methods: We included patients from stroke units at hospitals in the Central Norway Health Authority and from Haukeland University Hospital. We administered a selection of cognitive tests, and the patients completed a questionnaire 3 and 12 months post-stroke. Cognitive impairment was defined as impairment of ≥2 cognitive tests.

Results: A total of 324 patients completed the 3-month testing, whereas 37 patients were lost to follow-up at 12 months. The results showed significant improvement of cognitive function defined as impairment of ≥2 cognitive tests (P = .03) from months 3 to 12. However, most patients still showed cognitive impairment at 12 months with a prevalence of 35.4%. There is significant association between several of the cognitive tests and hypertension and smoking (P = .002 and .05). The prevalence of depression, but not anxiety, increased from 3 to 12 months (P = .04). The prevalence of fatigue did not change and was thus still high with 29.5% after 12 months.

Conclusions: This study shows that an improvement of cognitive function still occurs between 3 and 12 months. Despite this, the prevalence of mostly minor cognitive impairment still remains high 12 months after the stroke. The increasing prevalence of

depressive symptoms highlights the importance of being vigilant of depressive symptoms throughout the rehabilitation period. Furthermore, high prevalence of fatigue persisted.

KEYWORDS
cerebrovascular diseases, depression, mild cognitive impairement, psychiatry, quality of life, strokes

1 | INTRODUCTION

A majority of ischemic stroke patients have mild and quickly resolving, usually sensorimotor symptoms. National institute of health stroke scale (NIHSS) ≤5 is used as a definition of minor stroke in earlier publications[1] but a consensus on the definition is lacking. There is growing evidence that even minor strokes and transitoric ischemic attack (TIA) can cause persisting disabling cognitive symptoms.[2] A recent study found brain atrophy and cognitive decline after a TIA suggesting that even a transient cerebrovascular event leads to secondary damage in the brain[3] independent on the focal ischemic lesion.

Improvement of cognitive impairment occurs in a substantial amount of patients. One study found significant improvement of neuropsychological test results from baseline to 6 and 12 months, but significant and persistent residual cognitive impairment after minor stroke and TIA.[2] Patients with coronary artery disease, atrial fibrillation, and >50% stenosis of the internal carotid artery had the most severe cognitive impairment. A stroke registry study[4] reported cognitive functioning, using the Mini-Mental State Examination (MMSE), to be impaired in 13% of patients after 12 months.[4]

Minor strokes may also have psychological consequences. The prevalence of depression and anxiety 12 months after a minor stroke has been reported to be 26%[5] and 25%[6] 1 year after the stroke. Post-stroke fatigue was found in 34.7% of the patients at 12 months,[7] suggesting fatigue to be a relatively common and persistent complaint.

Cognitive and psychological symptoms are not necessarily detected before discharge and may first be recognized when the stroke patient meets demands in daily life.

Studies looking at improvement beyond 3 months are few. One study found that the recovery rate was greatest within the first 6 months but continued for up to 18 months for some patients.[8] Significant predictors of recovery included stroke severity, no history of previous stroke, diabetes, peripheral artery disease, women aged <65 years, and decreasing time between the stroke and the baseline assessment.[8]

A consensus of criteria for vascular cognitive impairment is also lacking. In one study, vascular cognitive impairment is proposed as a combination of cognitive disorder and history of vascular disease where the vascular disease is the dominant pathology behind the cognitive deficits.[9]

The aim of this study was to describe the prevalence and development of cognitive impairment, anxiety, depression and fatigue between 3 and 12 months after an ischemic stroke, and factors associated with persisting symptoms.

2 | MATERIAL AND METHODS

Ischemic stroke was defined according to the Baltimore-Washington Cooperative Young Stroke Study Criteria[10] comprising neurological deficits lasting more than 24 hours because of ischemic lesions, or transient ischemic attacks where CT or MRI showed infarctions related to the clinical findings. Inclusion criteria: To include subjects in working age, patients 18-70 years with minor ischemic stroke with preserved function in the range of the modified Rankin Scale (mRS) 0-2 were chosen.

Emotional impairment is used to define anxiety and/or depression.

2.1 | Recruitment

Patients were recruited consecutively from stroke units at Molde Hospital, Haukeland University Hospital, and St Olav's Hospital. Patients from other participating stroke units in hospitals in the Central Norway Health Authority (department of neurology at St Olav's Hospital, department of medicine at Kristiansund, Volda, and Ålesund Hospitals) were included whenever practical, but not always consecutively. The recruitment period lasted from Janaury 1, 2013 to December 31, 2016.

2.2 | Exclusion criteria

Patients with a major stroke defined as mRS >2 day 7/at discharge if before and patients with deterioration in mRS to more than 2 in the observational period of any cause were excluded.

2.3 | Baseline investigation

The patients underwent routine examination with NIHSS[11] and risk factors including hypertension, diabetes mellitus, hypercholesterolemia, smoking, overweight, and brain imaging with CT and/or MRI. They were treated according to Norwegian guidelines for ischemic stroke. Most patients with mRS ≤2 after 7 days/at discharge if earlier had no need for further rehabilitation and were discharged to their home.

Prestroke mRS and prevalence of anxiety and depression were registered.

Demographic data were collected from the initial hospital stay.

2.4 | Assessment of cognitive and emotional function

2.4.1 | Global and visuospatial cognitive function

Mini-Mental State Examination[12] and clock drawing test[13] were used as a screening of global cognitive function. Clock drawing test assesses also visuospatial function.[13]

Executive function was tested with trail-making A and B,[14] color-word interference test, and verbal fluency. The color-word interference and verbal fluency tests are subtests from the Delis-Kaplan Executive Function System (d-kefs) neuropsychological test battery.[15]

Memory was tested with the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) ten-Word learning task.[16]

Cognitive impairment was defined as impairment of ≥2 cognitive tests.

Scores below 1.5 SD of the mean were characterized as abnormal.

The Ullevål aphasia screening test was used to test aphasia.[17]

Informant questionnaire for cognitive decline in the elderly (IQCODE) graded from 1 to 5 (much better, better, unchanged, worse, and much worse) was registered at 3 months.

2.4.2 | Anxiety and depression

Hospital and Anxiety and Depression Scale (HADS) was used to assess anxiety (HADS-A) and depression (HADS-D).[18] A score ≥8 on HADS-A or HADS-D items indicates possible presence of anxiety or depression, with sensitivity and specificity about 0.80 for both scales,[19] and a total score ≥15 indicates combined anxiety and depression.

2.4.3 | Fatigue

Fatigue Severity Scale (FSS) was used to assess fatigue.[20] FSS is a nine-item questionnaire that assesses the effect of fatigue on daily living. Each item is a statement on fatigue that the subject rates from 1 "completely disagree" to 7 "completely agree."[21] Fatigue is defined as FSS score ≥5.[21]

Cognitive testing was performed by trained research nurses or by the neurologist responsible for the study.

Testing and completing of questionnaires was done at 3 and 12 months after onset of the stroke.

2.5 | Statistics

Correlation factor test, Mc Nemars test, and linear regression were used in the analyses.

In the linear regression analyses, change in results between 3 and 12 months was used as the dependent variable. Gender, age, and education were forced into each analysis to adjust for potential confounding. Analyses of other independent variables as number of risk factors, marital stage, and employment were done, but excluded because of lack of significant correlation.

STATA 14 (Statacorp) was used for analyses.

3 | RESULTS

In total, 325 ischemic stroke patients were included; 1 was excluded because of wrong diagnosis and 2 because of deterioration to mRS >2 at 12 months. Lost to follow-up between 3 and 12 months was 37 patients. The reason was mainly that patients did not meet their appointment. Table 1 shows baseline demographic data and vascular risk factors.

The mean age was 58 (SD 10) years. Baseline mRS was 0.3. Prevalent risk factors were hypertension (54%), BMI >25 (58%), hypercholesterolemia (47%), and smoking (35%). Assessment of function status by mRS score prestroke and day 7/at discharge was 0.3 (SD 0.6) and 1.1 (SD 0.8). National institute of health stroke scale day 7/at discharge was 0.8 (SD 1.0), at 3 months 0.2 (SD 0.6), and at 12 months 0.2 (SD 0.4). The mean value of the aphasia scores at 3 and 12 months was 51.7 (SD 1.1) and 51.8 (SD 1.0) of a total of 52 points.

The average number of impairment of cognitive tests at 3 and 12 months was 1.8 (SD 2.1) and 1.7 (SD 2.4).

Table 2 shows significantly lower prevalence of impairment in 10-Word test delayed recall, naming error test and impairment

TABLE 1 Baseline data

	Patients (%)
Total	324 (%)
Age (mean)	58.0 (SD 10.0)
Females	120 (37)
Males	204 (63)
Married/partner	244 (75)
Single	67 (21)
Widow/widower	12 (4)
Education (1, 2, 3)[a]	51 (16)
	148 (46)
	121 (37)
Employed before event	217 (67)
Anxiety and/or depression before event	46 (10)
Risk factors	
Hypertension	174 (54)
Diabetes mellitus	39 (12)
Atrial fibrillation	46 (14)
BMI mean (SD)	26.7 (4.4)
Overweight (BMI ≥25)	189 (58)
Hypercholesterolemia[b]	151 (47)
Smoking[c]	114 (35)
Prestroke mRS	0.3 (SD 0.6)
Baseline mRS (SD)	1.1 (SD 0.8)
Baseline national institute of health stroke scale (SD)	0.8 (SD 1.0)
Lost to follow-up	37 (11)

Note: [a]1 Primary school, 2 high school, 3 bachelor/university.
[b]Treatment with cholesterol-lowering medication.
[c]Current smoker or smoking within the last 12 mo.

TABLE 2 Prevalence of cognitive impairment, fatigue, anxiety, and depression at 3 and 12 mo (McNemars test)

	Prevalence 3 mo (%)	Prevalence 12 mo (%)	Odds ratio	*P*
Memory				
10-word learning task[a,b]	7.7	6.0	2	.2
10-word learning task, delayed recall[a,b,c]	14.0	7.8	2.9	.003
Executive function				
Trail-making A[a]	6.2	5.2	1.4	.6
Trail-making B[a]	15.0	11.5	1.5	.3
Verbal fluency[a]	14.2	11.2	1.8	.2
Color-word interference tests				
Color-word naming[a]	25.2	20.1	2	.07
Color-word reading[a]	18.7	18.1	0.8	.6
Color-word inhibition[a]	16.3	13.2	1.6	.2
Color-word inhibition/switching[a]	24.1	20.1	1.4	.2
Error scores				
Naming errors[d]	7.8	5.2	1.4	.04
Reading errors[d]	13.0	10.0	1.7	.09
Inhibition errors[a]	12.9	5.9	1.3	.7
Inhibition/switching errors[a]	6.9	8.7	0.6	.2
Impairment ≥2 cognitive tests	41.6	35.4	1.8	.03
Anxiety and depression				
HADS[e]	15	16	0.7	.3
HADS-A[f]	20	18	1.3	.4
HADS-D[g]	9	12	0.4 (2.6)	.04
Fatigue				
Fatigue Severity Scale (FSS)[h]	25.6	29.5	0.7 (1.5)	.2

Note: Correction for multiple variable testing is not done.
[a]Scaled score.
[b]Adjusted for age and educational level.
[c]Tested with 5-min delay.
[d]Cumulative percentage defined as 2 (naming errors) and 1 (reading error).
[e]Anxiety and/or depression defined as HADS ≥15.
[f]Anxiety was defined as HADS-A ≥8.
[g]Depression was defined as HADS-D ≥8.
[h]Fatigue defined as FSS ≥5.

in ≥2 cognitive tests after 12 months compared with 3 months. In contrast, the number of patients with HADS-D >8 increased significantly from 3 to 12 months.

Of a total of 15 cognitive tests, Table 3 shows a significant correlation between hypertension, five cognitive tests, and HADS-anxiety at 12 months. There was a significant correlation between diabetes mellitus and one cognitive test, and for BMI >25, there was a significant correlation with three cognitive tests. For atrial fibrillation and hypercholesterolemia, there were no significant correlations for any of the cognitive tests, HADS-A, HADS-D, or fatigue. There was a significant correlation between smoking and eight cognitive tests.

There was a significant correlation between increasing number of risk factors and 3 of 15 cognitive tests at 12 months, but no significant correlation with HADS-A, HADS-D, or fatigue (Table S1).

Table 4 shows the correlation between the difference in test results between 3 and 12 months and age, gender, education, and depression. There was a significant correlation between age and the difference in test results of 10-word learning task, and gender and the difference in inhibition/switching errors. For prevalence of depression at 12 months, there was a significant correlation between the difference in the trail-making A, 10-word learning task delayed, inhibition error, and inhibition/switching errors.

TABLE 3 Correlation between cognitive function, anxiety, depression, and fatigue at 12 mo and vascular risk factors (Spearmans test; *P*)

	Hypertension	Diabetes mellitus	BMI >25	Atrial fibrillation	Hyper cholesterolaemia	Smoking
Global cognitive function and visuospatial test						
MMSE[a]	−0.1 (0.02)	−0.08 (0.2)	−0.07 (0.2)	0.02 (0.6)	0.04 (0.5)	−0.1 (0.04)
Clock drawing test	−0.01 (0.9)	0.07 (0.3)	−0.06 (0.3)	−0.04 (0.5)	0.05 (0.4)	0.02 (0.8)
Memory						
10-word learning task[b]	−0.2 (0.003)	−0.04 (0.5)	−0.08 (0.2)	−0.01 (0.8)	−0.08 (0.2)	−0.09 (0.1)
10-word learning task delayed recall[c]	−0.1 (0.05)	0.02 (0.8)	−0.1 (0.06)	0.05 (0.4)	−0.05 (0.4)	−0.1 (0.1)
Executive function						
Trail-making A	0.1 (0.01)	0.06 (0.03)	0.09 (0.1)	0.05 (0.4)	−0.07 (0.2)	−2 (0.006)
Trail-making B	0.2 (0.002)	−0.03 (0.6)	0.2 (0.004)	0.04 (0.5)	−0.06 (0.3)	0.1 (0.03)
Verbal fluency	0.02 (0.8)	−0.05 (0.4)	−0.01 (0.9)	−0.05 (0.4)	−0.01 (0.9)	−0.1 (0.04)
Color-word interference tests						
Color-word naming[d]	−0.01 (0.9)	−0.07 (0.2)	−0.05 (0.4)	0.05 (0.4)	−0.02 (0.8)	0.1 (0.02)
Color-word reading[d]	−0.05 (0.4)	0.01 (0.9)	−0.04 (0.5)	−0.01 (0.8)	0.05 (0.4)	0.2 (0.01)
Color-word inhibition[d]	−0.07 (0.2)	−0.06 (0.3)	−0.06 (0.3)	0.05 (0.4)	0.02 (0.8)	0.2 (0.002)
Color-word inhibition/switching[d]	−0.02 (0.7)	−0.00 (1.0)	−0.01 (0.9)	0.06 (0.3)	0.05 (0.4)	0.1 (0.04)
Naming errors[e]	0.04 (0.5)	0.07 (0.2)	0.00 (0.9)	−0.02 (0.8)	−0.06 (0.3)	−0.01 (0.8)
Reading errors[e]	−0.03 (0.6)	0.03 (0.6)	0.03 (0.6)	−0.02 (0.7)	−0.05 (0.3)	0.05 (0.4)
Inhibition errors[d]	0.1 (0.04)	−0.1 (0.8)	0.1 (0.01)	−0.5 (0.3)	0.0 (0.7)	0.06 (0.3)
Inhibition/switching errors[d]	−0.01 (0.8)	−0.02 (0.6)	0.1 (0.04)	−0.02 (0.7)	0.7 (0.3)	0.5 (0.3)
Anxiety and depression						
HADS[f]	−0.08 (0.2)	0.05 (0.4)	−0.01 (0.8)	−0.02 (0.8)	0.01 (0.9)	0.00 (1.0)
HADS-A[g]	−0.2 (0.01)	0.09 (0.1)	−0.04 (0.4)	−0.05 (0.4)	−0.02 (0.8)	−0.04 (0.5)
HADS-D[h]	0.01 (0.9)	0.2 (0.8)	0.01 (0.9)	0.02 (0.7)	0.03 (0.5)	0.05 (0.4)
Fatigue						
Fatigue Severity Scale (FSS)[i]	−0.06 (0.3)	0.02 (0.7)	0.01 (0.8)	0.03 (0.7)	−0.02 (0.8)	0.1 (0.09)

Note: Correction for multiple variable testing is not done.
[a]Mini-mental state.
[b]Adjusted for age and educational level.
[c]Tested with 5-min delay.
[d]Scaled score.
[e]Cumulative percentage defined as 2 (naming errors) and 1 (reading error).
[f]Anxiety and/or depression defined as HADS ≥15.
[g]Anxiety was defined as HADS-A ≥8.
[h]Depression was defined as HADS-D ≥8.
[i]Fatigue defined as FSS ≥5.

4 | DISCUSSION

4.1 | Cognitive function

Table 2 shows a significant reduction in prevalence of impairment of ≥2 cognitive domains from 3 to 12 months. This may be the most important clinical finding confirming a certain improvement of cognitive function beyond 3 months. Nevertheless, 35% of the patients had persisting cognitive impairments after 12 months in the meaning of impairment of ≥2 cognitive domains. The number is high considering the low NIHSS at 12 months. However, the impairment is relatively mild on a group level, with an average number of impairment of cognitive tests of 1.7.

TABLE 4 Regression analyses of the difference (raw scores) between 12 and 3 mo, beta (*P*)

	Age	Gender	Education	HADS-depression (3 mo)
Global cognitive function and visuospatial test				
MMSE[a]	−0.11 (0.07)	0.08 (0.2)	−0.07 (0.2)	0.04 (0.5)
Clock drawing test	0.08 (0.2)	0.04 (0.5)	0.07 (0.3)	−0.08 (0.2)
Memory				
10-word learning task[b]	−0.15 (0.02)	−0.02 (0.7)	−0.11 (0.07)	−0.02 (0.7)
10-word learning task delayed recall[c]	−0.08 (0.2)	0.08 (0.2)	−0.08 (0.2)	−0.2 (0.001)
Executive function				
Trail-making A	0.003 (0.9)	0.06 (0.3)	0.08 (0.2)	−0.2 (0.001)
Trail-making B	−0.05 (0.5)	0.06 (0.4)	−0.08 (0.2)	0.1 (0.1)
Verbal fluency (FAS)	−0.09 (0.2)	−0.13 (0.04)*	0.03 (0.6)	−0.06 (0.3)
Color-word interference tests				
Color-word naming[d]	−0.08 (0.2)	0.04 (0.6)	−0.16 (0.008)	−0.03 (0.6)
Color-word reading[d]	0.08 (0.2)	−0.06 (0.3)	−0.10 (0.1)	−0.04 (0.5)
Color-word inhibition[d]	−0.02 (0.8)	0.06 (0.3)	−0.03 (0.6)	−0.05 (0.4)
Color-word inhibition/switching[d]	0.02 (0.8)	0.04 (0.5)	−0.08 (0.2)	0.07 (0.3)
Error tests				
Naming error[e]	−0.03 (0.6)	−0.05 (0.4)	0.04 (0.5)	0.01 (0.9)
Reading error[e]	−0.08 (0.2)	0.001 (0.9)	−0.14 (0.03)	0.03 (0.7)
Inhibition error[d]	0.06 (0.3)	−0.03 (0.6)	−0.04 (0.5)	0.16 (0.01)
Inhibition/switching error[d]	−0.02 (0.7)	−0.07 (0.2)	0.06 (0.3)	0.13 (0.04)
Anxiety and depression				
HADS[f]	0.07 (0.2)	0.09 (0.2)	−0.03 (0.6)	
HADS-A[g]	0.1 (0.1)	0.08 (0.2)	0.04 (0.5)	0.05 (0.4)
HADS-D[h]	0.02 (0.7)	0.08 (0.2)	−0.1 (0.1)	
Fatigue				
Fatigue Severity Scale (FSS)	0.05 (0.4)	0.02 (0.7)	−0.07 (0.3)	−0.08 (0.1)

Note: Correction for multiple variable testing is not done.
[a]Mini-mental state.
[b]Adjusted for age and educational level.
[c]Tested with 5-min delay.
[d]Scaled score.
[e]Cumulative percentage defined as 2 (naming errors) and 1 (reading error).
[f]Anxiety and/or depression defined as HADS ≥15.
[g]Anxiety was defined as HADS-A ≥8.
[h]Depression was defined as HADS-D ≥8.

Hypertension and smoking are the most important risk factors associated with long-term cognitive impairment such as impairment of memory and executive functions. Some earlier studies have found an association between hypertension and cognitive decline, while others did not. One large study however found that hypertension was associated with faster cognitive decline in persons at risk for dementia.[22] The study also found that intervening strokes did not explain these findings. Heavy smokers (>20 cigarettes daily) showed a faster decline in cognitive function than non-smokers in a previous study.[23] Smoking is also identified as a risk factor for reduced cerebral perfusion, cerebral atrophy, and cerebrovascular changes.[24] Another study found an association between smoking and the amount of neuritic plaques.[25]

We found no significant correlation between atrial fibrillation and cognitive impairment in contrast to another study.[26] The low

number of patients with atrial fibrillation in our study may explain why our results did not reach statistical significance.

Depressive symptoms at 12 months seem to have some effect on the cognitive function. This is as expected because cognitive symptoms is a common finding in depressive patients.[5,27]

The number of risk factors (hypertension, atrial fibrillation, smoking, diabetes mellitus, BMI >25) had a modest influence of the cognitive function at 12 months. Vascular risk factors are also associated with development of Alzheimer's disease.[28] Our patient was younger than a typical patient developing Alzheimer's disease and had a low NIHSS at follow-up at 12 months. The plasticity of the brain is higher and the risk of neurodegeneration lower at lower age. This may explain our findings. Twelve-month observation may also be a too short period to study the development of cognitive impairment.

The mean value of IQCODE at 3 months is 3 or unchanged (SD 0.3) compared with prestroke condition.

High prevalence of overweight may indicate that a considerable number of the patients also have obstructive sleep apnea syndrome (OSAS). OSAS may have cognitive and depressive symptoms[29] which may explain some of our findings, but our study has no data on this.

Depression may be a causal mechanism of cognitive impairment and fatigue as discussed in a previous study.[27]

The possibility of a learning effect of repeated cognitive or neuropsychological testing is described in previous studies,[30,31] and one study did not find a learning effect at 1-month test-retest interval.[31] The interval of 9 months for repeated testing in our study is probably too long to cause a significant influence on the results.

4.2 | Anxiety and depression

There was no significant difference in anxiety between 3 and 12 months, but the prevalence was relatively high with 20% and 18%. A previous study using the same questionnaire (HADS) and same cutoff score found a prevalence of anxiety in minor stroke patients of 25% at 12 months.[6]

The prevalence of depression was significant higher with 12% at 12 months in contrast to 9% at 3 months. This is in contrast to another study which found a decrease over time from 12.9% to 8.1% between 3 and 12 months.[32] Patient characteristics in this study were quite similar except higher NIHSS (2 vs 0.2). One study found a stable situation for depressive symptoms between 3 and 12 months.[33] In that study, population about 20% of the patients had mRS >2 in contrast to our study where mRS >2 was an inclusion criterion and patients were older than our patients. This makes a comparison difficult. Early identification and treatment of depression is important as it may reduce the cognitive symptoms.

High prevalence of both cognitive impairment and fatigue at 12 months may contribute to the increase in depressive symptoms. Patients with persisting cognitive symptoms and fatigue with negative impact on daily life activities may be more prone to develop a depression over time, even though the impairment is minor.

There was no correlation between development of anxiety and prevalence of depression at 12 months, in contrast to previous studies.[34] A considerable amount of our patients had persisting depressive and/or anxiety symptoms 12 months post-stroke (Table 2).

4.3 | Fatigue

We found no significant difference in fatigue between 3 and 12 months. The prevalence was still high after 12 months (29.5%). A previous study found that 77.3% of their patients reporting fatigue at 6 months still reported fatigue at 12-month follow-up.[7] Fatigue is a disabling condition, and persistent fatigue is therefore important to identify. Surprisingly, there was no correlation between fatigue and cognitive impairment in our study in contrast to another study.[7] A possible explanation is that the tools used to measure fatigue are different (FSS vs FAI: Fatigue Assessment Instrument). FAI is more detailed and may be more sensitive to detect significant correlations.

4.4 | Strengths and weaknesses

One strength of this study is the large number of patients. It is a well-defined study cohort based on the functional classification. There were relatively few dropouts between 3 and 12 months. It is a multicenter study and reflects minor stroke patients in the middle and western part of Norway. Different study nurses performed the testing because of the multicenter design. This may create an inter-rater variability.

We do not have information about the patient's previous state, and there might be a possibility that an earlier stroke can influence on the results. Informant questionnaire for cognitive decline in the elderly was not registered at baseline. A possibility of preexisting cognitive impairment, for example, early Alzheimer's disease may therefore be a bias.

Prestroke fatigue and obstructive sleep apnea were not recorded.

The learning effect of repeated cognitive testing has to be considered.

Depression and anxiety were based on self-report (HADS), and no diagnostic interviews were performed.

5 | CONCLUSION

This study shows a small, but significant improvement in cognitive function from 3 to 12 months. However, the prevalence of mild cognitive impairment was still high at 12 months. The most important risk factors for persistent cognitive impairment were hypertension and smoking.

The prevalence of depression increased from 3 to 12 months. Early detection and treatment of depression is important to contribute to recovery including improvement of cognitive symptoms.

Fatigue remains a persistent symptom with a high prevalence 1 year after a minor stroke.

Overall, the findings in our study emphasize the importance of a longer term follow-up of patients with minor stroke. This is not done routinely today. For the future, we suggest a follow-up with a test battery testing memory and executive functions because these are functions of great importance in the daily living. We also recommend a screening for fatigue, anxiety, and depression.

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CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

HN is the main supervisor. He has been involved in protocol development, gaining ethical approval, data analysis, and the first draft of the manuscript. HE is a co-supervisor and has been involved in protocol development and advice in the study period. AG is a neuropsychologist and has been involved in protocol development, especially the selection of cognitive tests and data analysis and interpretation. MTR is a neuropsychologist and has been involved in data analysis and interpretation. RM is a co-supervisor and has been involved in protocol development. SBS has been involved in the protocol development, especially the selection of cognitive tests. EJ has been involved in the protocol development with focus on anxiety and depression tests. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

ETHICAL APPROVAL

The ethics committee of Rogaland, Hordaland and Sogn and Fjordane (REC west) approved this study (REC number: 2012/1708).

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

INFORMED CONSENT

Written informed consent was obtained from the patients for their anonymized information to be published in this article.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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