

Original Research Article

Montreal Cognitive Assessment in a 63- to 65-year-old Norwegian Cohort from the General Population: Data from the Akershus Cardiac Examination 1950 Study

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Keywords

Cognitive screening test · Cognitive function · Montreal Cognitive Assessment · General population · Population-based study

Abstract

Aims: To investigate Montreal Cognitive Assessment (MoCA) test scores in a cohort aged 63–65 years from a general population in relation to the proposed cut-off score of 26 for mild cognitive impairment (MCI) and to explore the impact of education. **Methods:** MoCA scores were assessed in the Akershus Cardiac Examination 1950 Study, a cross-sectional cohort study of all men and women born in 1950 living in Akershus County, Norway. The participants were aged 63–65 at the time of data collection. **Results:** MoCA scores were available in 3,413 participants, of which 47% had higher education (>12 years). The mean MoCA score was 25.3 (95% confidence interval [CI] 25.2–25.4), and 49% had a score below the suggested cut-off of 26 points. Those with higher education had significantly higher scores (mean 26.2, 95% CI 26.1–26.3 vs. 24.4, 95% CI 24.3–24.6, $p < 0.001$). **Conclusions:** Approximately 50% scored below the cut-off score of 26 points, suggesting that the cut-off score may have been set too high to distinguish normal cognitive function from MCI. Educational level had a significant impact on MoCA scores.

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Introduction

Cognitive decline and dementia due to Alzheimer disease (AD) as well as cerebrovascular disease are expected to become much more prevalent in the years to come [1], with increasing global socioeconomic impact [2]. According to the World Alzheimer Report from 2015, approximately 47 million people are living with dementia worldwide, and this number is estimated to nearly triple by 2050 [1]. In addition, vascular contribution to cognitive dysfunctions is suspected to increase. Since there is a lack of effective treatments for most dementia disorders, focus on early detection and prevention is demanding. Identification of individuals at risk for cognitive decline or with early stages of dementia for targeting known risk factors may preserve brain health [3]. Several cognitive assessment tools are available to screen for and identify cognitive impairment and dementia, but most of them are developed for identification of degenerative diseases at more advanced stages. Screening tools should include a comprehensive cognitive battery, but they may be challenging to use in order to differentiate between underlying pathologies. The well-known and probably most used cognitive screening test is the Mini-Mental State Examination (MMSE). This test is, however, of limited value in the early phase of mild cognitive impairment (MCI) and cognitive impairment of vascular aetiology [4, 5]. MMSE does not assess executive function, which is commonly affected in patient with vascular cognitive impairment (VCI) [6] and other cognitive disorders such as frontotemporal dementia and Lewy body dementia [7].

The Montreal Cognitive Assessment (MoCA) test is a brief measure of global cognitive function developed to detect early suspected cognitive deficits. The test is easy to administer, score, and interpret. It takes only a few minutes to perform and is suitable for use as a screening tool to identify patients with MCI and VCI in hospitals, in outpatient clinics, and by general practitioners [8–10]. The MoCA has been validated for people aged 55–85 years, is translated into several languages, and is extensively used in different parts of the world. In addition, MoCA has a high test-retest reliability and good internal consistency [8]. It measures different cognitive domains, including attention, concentration, executive functions, memory, language, visuoconstructive skills, abstract thinking, numeracy, and orientation. Compared to the MMSE, MoCA covers all the cognitive domains, including executive functioning, with better sensitivity and specificity in patients with MCI [8–11]. Further, MoCA shows comparable results to the MMSE in patients with mild AD [8, 12]. The maximum score is 30, and a score ≥ 26 is interpreted as normal cognitive functioning. The publisher of MoCA has recommended a MoCA cut-off score of < 26 for both MCI and AD [8]. Patients with MCI showed a mean score of 22.1 and patients with AD a mean score of 16.2 [8]. The MoCA score is proposed to be used for grading of the severity of diagnosed cognitive impairments, and a score ≥ 17 may be used to distinguish MCI from dementia [13]. Further, the cut-off score of < 26 was chosen for MCI due to an observed high sensitivity and specificity [8]. However, this cut-off score has been questioned [14]. A Cochrane analysis from 2015 found a high sensitivity of 94%, but a low specificity of 60% or less for this cut-off score [14]. The authors concluded that there was insufficient evidence to give a clinical recommendation regarding a specific cut-off score [14]. Other studies have suggested that a lower cut-off score is more suitable. Therefore, normative data from large population-based studies are needed to decide the most appropriate cut-off score between normal functioning and cognitive impairment on the MoCA test [15, 16].

The MoCA test score is influenced by demographic data such as nationality, gender, age, and education [16–18]. Male gender and low education levels are associated with poorer score on the MoCA [17], the latter supposedly due to an educational component in cognitive testing. In the original work from Nasreddine et al. [8], a 1-point education compensation is suggested for those with ≤ 12 years of education. In addition, symptoms of depression may influence cognitive performance [19, 20]. The aim of the present study was to investigate

MoCA test scores in a large middle-aged cohort from the general Norwegian population in relation to the recommended cut-off score, and to explore the impact of educational level and gender.

Methods

Participants

All participants were born in 1950 and were part of the Akershus Cardiac Examination (ACE) 1950 Study, a prospective, population-based cohort study of the cerebro- and cardiovascular health of all men and women born in 1950 in Akershus County, Norway. The study cohort is seen as a middle-aged population [21]. This particular age group was selected because the incidence of cardiovascular disease and cognitive impairment is still low but is expected to increase rapidly as the subjects grow older. The participants were examined at Akershus University Hospital (4,122 eligible subjects) and Bærum Hospital, Vestre Viken Hospital Trust (1,705 eligible), from June 2013 to May 2015.

Assessments

The design of the ACE 1950 Study is described in detail elsewhere [22]. Briefly, at the time of data collection, all participants were subjected to an interview regarding educational level, medical history (including self-reported cerebrovascular disease), and lifestyle, as well a clinical examination. Higher education was defined as >12 years of formal education. Depression was assessed using the 7-item depression subscale of the self-reporting questionnaire, the Hospital Anxiety and Depression Scale (HADS) [23]. Each item was scored from 0 to 4, and according to previously established cut-off scores, the sum score was categorized into normal (<8), possible clinical relevant depressive symptoms (8–10), and probable clinical relevant depressive symptoms (>10).

The cognitive screening battery was chosen to assess all cognitive domains: (1) the 10-item wordlist test from the Consortium to Establish a Registry for AD (CERAD) neuropsychological battery [24], (2) the Trail Making Test A and B (TMT-A and -B) [25], and (3) the MoCA [8], performed in this order in all subjects. The brief neuropsychological assessments were administered by highly trained study nurses. The Norwegian 7.1 version of the MoCA test (available at www.mocatest.org) was used [26]. Participants with insufficient Norwegian language skills, anamnestic and/or known cognitive impairment/dementia based on hospital records, or other brain diseases were excluded from the analyses. The total sum score of MoCA is reported as raw score (defined as the score before using a 1-point education correction) or as education-corrected score. The MoCA results were evaluated in relation to the recommended cut-off score of 26 points [8]. A MoCA score <17 is suggested as a cut-off score to distinguish MCI from dementia [13], and was interpreted as a low test result in this study.

Statistical Analysis

Descriptive demographic and clinical measures are shown as mean \pm standard deviation (SD), or as numbers and frequencies. MoCA scores are given as mean and 95% confidence interval (CI), and as median and interquartile range (IQR). An extra score point was added to the total MoCA score for subjects with ≤ 12 years of formal education. The independent sample *t* test was used to compare gender and education differences in the MoCA score as well as to compare the differences in MoCA score after excluding those with low test results. One-way ANOVA was used to compare the variance within the 3 HADS depression categories in relation to the MoCA score. A significance level was set at $p < 0.05$. All analyses were performed using IBM SPSS Statistic 23 software.

Table 1. Study population characteristics

Data type	With complete MoCA test (<i>n</i> = 3,413)
Demographic data	
Age, years	63–65
Male gender	52.0
Cardiovascular risk factors	
Hypertension	58.3
Coronary heart disease	7.0
Obesity (BMI >30)	22.7
Stroke/TIA	3.8
Daily smoking	14.1
Diabetes mellitus	9.9
Education >12 years	47.4
Physical activity >30 min daily (all daily activity incl. work)	84.7
Daily physical exercise	17.2
HADS depression sum score	
<8	94.5
8–10	3.9
>10	1.6
Cognitive performance	
TMT-A, s	38.0 (37.5–38.4)
>60 s	5.3
TMT-B, s	96.4 (94.8–98.1)
>188 s	4.2
10-item wordlist sum score	22.1 (22.0–22.2)
≤16	5.8
10-item wordlist delayed recall	7.4 (7.4–7.5)
≤5	13.8

Values are percentages unless otherwise indicated. Values in parentheses are 95% CI. Coronary heart disease, self-reported history of myocardial infarction, or cardiac bypass surgery or PCI with or without stent implantation; BMI, body mass index; TIA, transient ischemic attack; hypertension, mean blood pressure >140/90 mm Hg in sitting position after 10 min rest and/or use of antihypertensive drugs; diabetes, HbA_{1c} ≥6.5% and/or fasting plasma glucose ≥7.0 mmol/L and/or use of glucose-lowering medication; HADS, Hospital Anxiety and Depression Scale; TMT A and B, Trail Making Test A and B; 10-item wordlist list, test from The Consortium to Establish a Registry for Alzheimer’s Disease (CERAD) neuropsychological battery.

Results

After inviting 5,827 participants, a total of 3,706 subjects were included in the ACE 1950 Study (attendance rate 64%). The remaining 36% were non-responders or declined to participate with no further explanations. After excluding 293 patients with missing data due to personal preference (*n* = 212), language problems (*n* = 74), or known cognitive impairment (*n* = 7), 3,413 (92%) completed the MoCA test.

All included participants were born in 1950 and were 63–65 years of age at enrolment; 1,774 participants (52%) were men, 1,615 (47%) had higher education, 3,381 (99%) were Caucasians, and 126 (4%) had a history of self-reported cerebrovascular disease. Characteristics of the study population are presented in Table 1, and include measures of the other cognitive assessments and distributions of the HADS depression subscore.

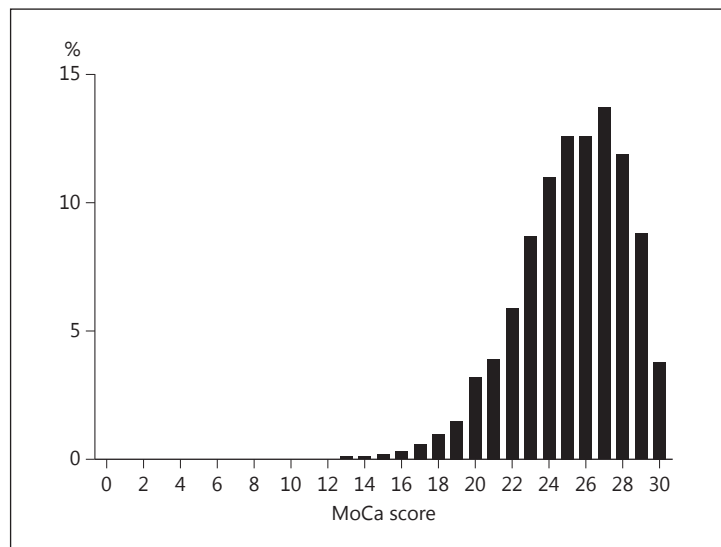


Fig. 1. Montreal Cognitive Assessment (MoCA) raw score distribution.

Table 2. MoCA score (\pm SD) before and after a correction for education

	MoCA raw	Correction for education
MoCA score		
Total	25.3 \pm 2.9	25.8 \pm 2.8
Education \leq 12 years	24.4 \pm 3.1	25.4 \pm 3.0 (+ 1 point)
Middle school, education \leq 10 years	23.5 \pm 3.4	25.4 \pm 3.3 (+ 2 points)
High school, education 10–12 years	24.8 \pm 2.8	25.8 \pm 2.8 (+ 1 point)
Education >12 years	26.2 \pm 2.5	26.2 \pm 2.5

MoCA, Montreal Cognitive Assessment; SD, standard deviation.

The mean MoCA raw score was 25.3 (95% CI 25.2–25.4). The overall distribution of MoCA scores is shown in Figure 1. The median MoCA score value was 26 (IQR 23–27). In total, 1,676 (49%) of the participants from a general population had a score below the suggested cut-off score for MCI of 26 points. There was a significant gender difference, with women achieving a significantly higher score than men (mean 25.5, 95% CI 25.4–25.6 vs. 25.0, 95% CI 24.9–25.2, $p < 0.001$), independent of education level.

Excluding those with a MoCA score < 17 ($n = 23$) did not change the MoCA raw score significantly (mean 25.3, 95% CI 25.3–25.4, median 26, IQR 24–27, $p = 0.163$).

Educational level had a significant impact on the MoCA test results. Those with higher education scored significantly higher compared to those with ≤ 12 years of education (mean 26.2, 95% CI 26.1–26.3, median 27 vs. mean 24.4, 95% CI 24.3–24.6, median 25, $p < 0.001$). After adding 1 point for individuals who had ≤ 12 years as suggested in the test manual, the difference was partially equalized (mean 25.4, 95% CI 25.3–25.5, median 26). However, the MoCA score was still significantly higher among those with higher education ($p < 0.001$) (Table 2).

We found a significant difference between subgroups of those with ≤ 12 years of education. Those with middle school (≤ 10 years) or similar scored lower compared to those with high school or similar (10–12 years) (mean 23.5, 95% CI 23.2–23.7, median 24 vs. mean

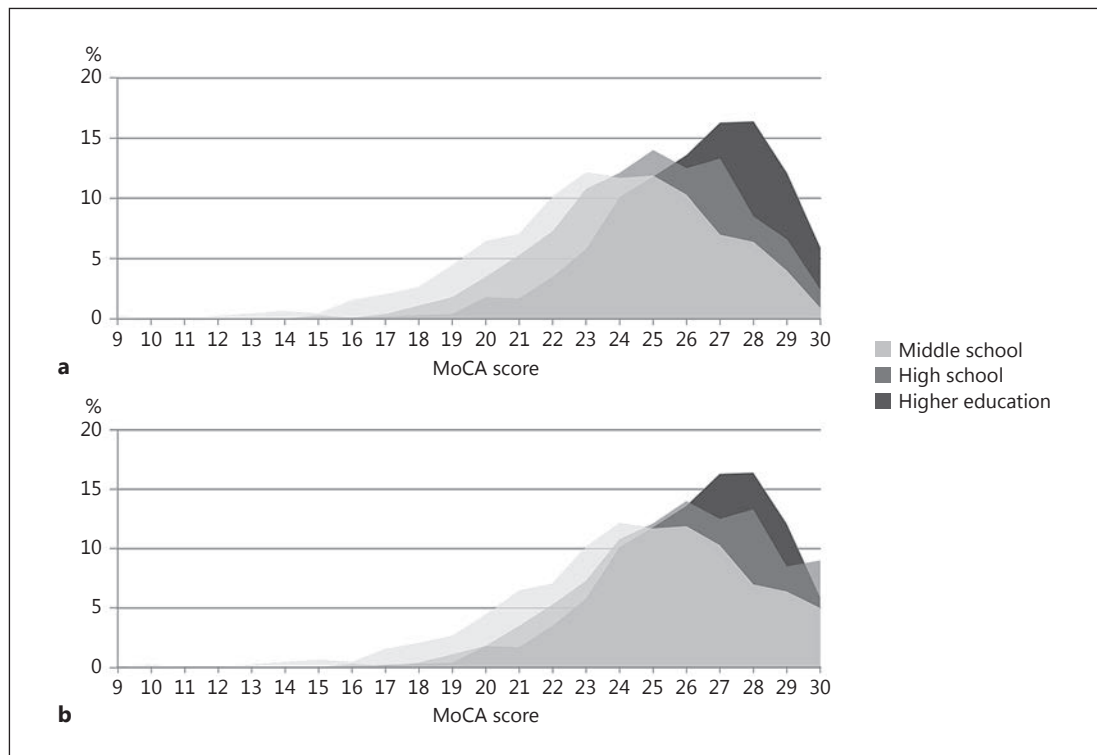


Fig. 2. Montreal Cognitive Assessment (MoCA) raw score distribution in relation to education (a) and after a 1-point education correction for ≤ 12 years of education (b). Middle school, ≤ 10 years of education; high school, 10–12 years of education; higher education, > 12 years of education.

Table 3. MoCA raw score (\pm SD) in relation to gender and education

	Male	Female	<i>p</i> value
Middle school, education ≤ 10 years	23.0 \pm 3.4	23.7 \pm 3.3	0.01
High school, education 10–12 years	24.5 \pm 2.8	25.2 \pm 2.7	< 0.001
Higher education	25.9 \pm 2.5	26.6 \pm 2.4	< 0.001

MoCA, Montreal Cognitive Assessment; SD, standard deviation.

24.8, 95% CI 24.7–25.0, median 25, $p < 0.001$). The distribution of the MoCA scores in relation to gender and educational level are shown in Table 3 and Figure 2, respectively. Educational level also influenced the TMT-A (mean 36.4, 95% CI 35.7–37.0, median 34 vs. mean 39.3, 95% CI 38.6–40.0, median 36, $p < 0.001$), TMT-B (mean 86.1, 95% CI 84.4–87.8, median 79 vs. mean 105.7, 95% CI 103.1–108.4, median 91, $p < 0.001$), and the 10-item wordlist (mean 23.0, 95% CI 22.9–23.2, median 23 vs. mean 21.3, 95% CI 21.1–21.4, median 21, $p < 0.001$) test results.

The mean MoCA raw scores according to HADS depression categories were 25.2 (95% CI 25.1–25.3, median 25), 25.6 (95% CI 25.2–26.1, median 26) and 25.7 (95% CI 24.9–26.5, median 27) in persons with a sum score < 8 , 8–10, and > 10 , respectively. The difference between categories was not statistically significant ($p = 0.107$).

Discussion

The mean MoCA raw score in a general population at the age of 63–65 years was 25.3, with a median of 26. Half of the population had a MoCA score below the suggested cut-off score of 26 points. After adding an extra point for persons with 12 years of education or less as suggested, those with higher education still had higher scores, and 42% scored below the cut-off score of 26 points. Participants with ≤ 12 years of education showed great variation in the MoCA results. Further, there was a significant difference between ≤ 10 years of education compared to 10–12 years. In addition, women had significantly higher MoCA scores, while depressive symptoms did not influence the MoCA results. To our knowledge, this is the largest study that has reported the results of the MoCA test as a screening tool in a general population [15, 16].

Demographic variables seem to influence the MoCA score, with great variation in test results in different countries. Therefore, population-based data for MoCA scores are needed. The present study provides data from a middle-aged Norwegian cohort. The study cohort is considered rather healthy and well educated. Despite this, nearly 50% scored below the suggested cut-off score of 26 points. When such a large proportion of the population scores below the recommended cut-off score, a MoCA cut-off score of 26 is probably not suitable to distinguish normal cognitive function from MCI when used as a screening tool in a general population. The suggested cut-off score of 26 was based on a sample of 90 healthy Canadian controls with a mean age of 73 years and mean education of 13 years. Using this cut-off score, the MoCA showed a sensitivity of 90% in MCI patients, a sensitivity of 100% in AD patients, and a specificity of 87%. They concluded that a cut-off score of 26 reflected the best balance between specificity and sensitivity [8]. Another population-based study from Dallas, TX, USA, including 2,653 subjects with a mean age of 50.3 years, found a mean MoCA raw score of 23.4 [15]. Here, 66% scored below 26. In addition, the MoCA score correlated with education. These findings are in line with a recent study, where the MoCA score was evaluated in relation to age and education and 46% scored below 26 points [27]. Further, 1,977 subjects in Japan with a mean age of 73.6 years and mean education of 11.0 years showed a mean MoCA score of 21.8, where 83% scored below 26 points [28]. Finally, an Italian population with mean age of 57 years and mean education of 11.1 years showed a mean MoCA score of 22.0 [16]. Consistently in these population-based studies is a mean MoCA score < 26 points, with a large proportion of the general population scoring below this cut-off score. These studies also show a clear association between education level and the MoCA score, which is confirmed by our study.

Usually, cognitive screening tests are performed in selected populations, i.e., groups with anamnestic cognitive complaints, organic disease, or suspected cognitive deficit. It is reasonable to assume that a selected population will differ from the general population in many ways, also in test results. However, several studies that include cases with cognitive impairment show the same trend as the population-based studies [9, 29, 30]. In general, the prerequisite for a good screening test is high sensitivity and specificity. The same is important in the diagnostic process in patients presenting with symptoms and signs of disease. This implies the need for a high sensitivity and a relatively high MoCA cut-off score, as outlined by Nasreddine et al. [8] in the examination for suspected cognitive impairment caused by dementia disorder. In a clinical setting, the initial screening should then be followed by a comprehensive test battery if the result is positive. However, dementia disorders are progressive diseases with no cure, and therefore, higher precision in screening for cognitive impairment should be preferred to avoid false-positive test results. Consequently, we recommend the use of a more clinically meaningful cut-off score with higher specificity. Our findings, as well as the similar studies listed above, suggest that the MoCA cut-off score of 26 may be set too high.

Our data show lower MoCA scores among those with ≤ 12 years of education compared to those with higher education. This difference was partially equalized after adding a 1-point

education correction, implicating that such a correction is meaningful. Further, our results revealed heterogeneity among participants with ≤ 12 years of education, with significantly lower test scores among those with only middle school or similar. In this group, the difference was equalized if adding 2 education points (Table 2). The influence of education levels on cognitive test results is both logical and shown in several studies [18, 19, 28, 31]. Based on our findings, it seems reasonable to differentiate more between different levels of education and perhaps add 2 extra points for those with only middle school or similar.

There is conflicting evidence regarding the impact of gender on the MoCA test results [17, 18, 28]. We found a numerically small, yet statistically significant, gender difference in the MoCA score. Depression is an important differential diagnosis in cognitive impairments, and is also documented to influence cognitive screening test results [32], including MoCA in patients with cognitive impairments [20, 33]. It is hypothesized that executive function, in particular, is affected by depressive symptoms, which also may affect global cognitive function scores. However, in our study, neither possible nor probable clinically relevant depressive symptoms were associated with lower MoCA score. This is in line with another general population-based study [34], and indicates that the influence of depression on global cognitive measures varies according to patient populations.

The main limitation of our study is that it was not designed to evaluate the cut-off score with sensitivity and specificity due to the lack of known diagnoses of MCI and dementia. Further, the MoCA test was conducted as the last of 4 tests during the study inclusion (after the 10-item wordlist test and TMT-A and -B), where the 10-item wordlist test may have interfered with the delay recall test and TMT-B with the trail making/visuoconstructive part of the MoCA test results. In addition, we used the official Norwegian version of the MoCA where traditional animals are absent. The strength of this study is the large number of participants and that the MoCA test was performed by highly trained investigators. An attendance rate of 64% is considered acceptable and in line with other Norwegian population-based studies [35–37]. An important aspect of this cohort is that the non-responders did not differ from the participants in terms of education [38]. Test results of the TMT-A and -B tests and the 10-item wordlist test underline a normal cognitive function in the study cohort (Table 1). Demographically, the population is considered to comprise a cross-section of the Norwegian population, but with a slightly higher educational level [38].

Conclusion

This study provides data for the MoCA test in a middle-aged Norwegian community-based population. Since the mean MoCA score was 25 and half of the population had a score of less than 26, our findings indicate that the cut-off score for cognitive impairment may be too high and must be interpreted with caution. Furthermore, we confirmed that education level and gender affect the MoCA score. Therefore, we suggest a correction based on different educational levels, adding 1 point in the group with 12 years and 2 points for those with only middle school education. There is a need for further studies exploring the impact of education on the MoCA test.

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Statement of Ethics

The study was approved by the Regional Committees for Medical and Health Research Ethics in Norway (Ref. No. 2011/1475). All participants signed a written informed consent before entering the study. The study is recorded at Clinicaltrials.gov (NCT01555411).

Disclosure Statement

All authors completed the ICMJE (International Committee of Medical Journal Editors) Conflict of Interest form and declare that PhD fellow Håkon Ihle-Hansen received a PhD scholarship from the non-governmental patient organization Norwegian Health Association (“Nasjonalforeningen for Folkehelsen”) for this study. No other support was received from any organization for the submitted work. There were no financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years, and no other relationships or activities that could appear to have influenced the submitted work. The funding sources had no role in the study concept or design, the acquisition, analysis, or interpretation of data, or the preparation of the manuscript.

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