

Dementia risk among Mongolian population with type 2 diabetes: a matched case-control study

Munkh-Undral Munkhsukh^{1,†}, Darisuren Namjil^{2,†}, Puntsagdulam Byambajav², Enkh-Amgalan Angarag³, Suvd Junai¹, Byambasuren Dagvajantsan^{2,*,†}, Oyuntugs Byambasukh^{1,3,*,†}

¹Department of Endocrinology, School of Medicine, Mongolian National University of Medical Sciences, 13270 Ulaanbaatar, Mongolia

²Department of Neurology, School of Medicine, Mongolian National University of Medical Sciences, 13270 Ulaanbaatar, Mongolia

³Graduate School, Mongolian National University of Medical Sciences, 14210 Ulaanbaatar, Mongolia

*Correspondence: byambasuren@mnums.edu.mn (Byambasuren Dagvajantsan); oyuntugs@mnums.edu.mn (Oyuntugs Byambasukh)

† These authors contributed equally.

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People with diabetes have a higher risk of cognitive impairment than people without diabetes, and recently it is being considered a complication of diabetes mellitus (DM). Because of drastic lifestyle changes in the Mongolian population, diabetes prevalence is increasing rapidly. The rapid increase of diabetes prevalence and its poor control in Mongolia suggest that there might be significant cognitive impairment in the diabetes population. In this case-control study, we compared the Mini-Mental State Examination score to the risk of cognitive impairment, indicating vascular dementia in people with and without diabetes. Upon obtaining their informed consent, each subject was tested with Mini-Mental State Examination. We involved age and gender-matched diabetic ($n = 131$) and non-diabetic ($n = 131$) subjects. The mean age was 61.3 ± 8.5 and 61.0 ± 8.7 in people with and without diabetes, respectively, and 35.9% of the participants were male. According to study groups, the Mini-Mental State Examination scores were significantly different: 26.1 ± 3.7 and 27.5 ± 2.6 for people with and without diabetes, respectively. In logistic regression analysis, age was significantly associated with Mini-Mental State Examination score (Beta coefficient = 1.22; 1.11–1.35, $P < 0.001$) in people without diabetes after adjustments for potential confounders. However, age was not significantly associated with MMSE scores in people with diabetes mellitus. Thus, diabetes duration and poor control may contribute to developing cognitive impairment in people with diabetes. In conclusion, there might be a high prevalence of vascular dementia in people with type 2 diabetes mellitus. However, since Mini-Mental State Examination is sensitive to dementia and not specific to vascular dementia, further studies involving neuroimaging and neurological examination are needed to fully elucidate the link between type 2 diabetes and vascular dementia in a Mongolian population.

Keywords

Diabetes; Mini-Mental State Examination; Cognitive impairment; Dementia

1. Introduction

According to the WHO, the number of cases of diabetes amounted to 422 million in 2014 which is 8.4% among adults globally. There is an estimate that this number will increase to 578 million in 2030, 10.2% among adults [1, 2]. While there were no cases of diabetes detected in Mongolia in 1950, the prevalence of diabetes has been increasing dramatically since 1990 due to lifestyle and socioeconomic changes and urbanization. In 1999, Suvd Junai [3] determined the prevalence of type 2 diabetes in Mongolia showed a prevalence of 3.1% for diabetes and 9.2% for impaired glucose tolerance. It had been continuously increased and present with a prevalence of 8.3% for diabetes, 17.4% for impaired fasting glycemia reportedly in WHO-NCD Stepwise survey 2019 [3, 4].

Many disorders can present with cognitive impairment (CI). It is mainly categorized as cognitive impairment (CI) and dementia (vascular dementia, Alzheimer's disease etc.) [5–7]. According to the WHO, 47.47 million people worldwide have dementia. The estimated number of people with dementia will reach 75.63 million in 2030 and 135.46 million in 2050 [8]. Global population growth and aging globally are contributing factors to the higher prevalence of cognitive impairment. However, there is also an increasing prevalence of vascular diseases, such as diabetes mellitus (DM), one of the causes of the high prevalence of vascular cognitive impairment [7, 9]. Furthermore, a recent review article concluded that cognitive impairment, including dementia is a new emerging complication of diabetes, especially from the diabetologist's perspective [7]. The rapid increase of diabetes prevalence and poor control in Mongolia, suggests that there might be a significant level of cognitive impairment in the diabetic population. Therefore, we elucidated the risk of the cognitive impairment by comparing it in the DM and non-DM subjects.

2. Materials and methods

2.1 Data source and Mongolian population

We conducted a case-control study within two groups of 40–80-years old subjects, one with and without type 2 diabetes in Ulaanbaatar. Sample size calculation was based on the “Strengthening the Reporting of Observational Studies in Epidemiology” (STROBE) guidelines for reporting case-control studies [10]. We estimated, a priori, that the prevalence of dementia would be 15% in nondiabetic subjects and 30% in diabetic subjects. We used a significance level of 5% and a power of 80%. Finally, the sample size was 131 subjects in each group. The patients with type 2 diabetes were randomly selected during their outpatient routine clinical examinations in the Mongolia-Japan Teaching Hospital from 1st of June to 30th of August 2020. The inclusion criterion was if they were currently aged 40 years or over. The control group consisted of individuals with a normal glucose tolerance level confirmed by an endocrinologist and matched 1 : 1 by age and gender. The following pre-existing conditions constituted exclusion criteria: stroke, neurodegenerative disease, multiple sclerosis, cranial trauma, cancer, paraneoplastic cancer, neurosurgery, alcohol-related depression, Parkinson’s disease, and depression determined by Tsung test >70 scores [11].

According to the Helsinki Declaration, the study was conducted, and the medical ethical committee approved it of the Mongolian National University of Medical Sciences (METC No13-03/1A). Furthermore, all participants provided their written informed consent.

2.2 Variables and measurements

Cognitive function assessment: Cognitive function was evaluated with the Mini-Mental State Examination (MMSE) [12]. The MMSE consists of 11 cognitive function domains, including: orientation (2), retention (1), attention and calculation (1), recall (1), language (5), and copying (1), with a total score of 30 points. Dementia was defined as the participants scoring 24 points or below. We used a Tsung test with 20-question as an additional measure to assess the level of depression. Each of the 20 questions has answer options, including not at all, ranging from slightly disagree, slightly agree, definitely agree, and the depression was defined as scoring 70 points or more.

Covariates and other variables: The education level was categorized as low, medium, and high. Participants in the lower level of education group included no formal education and graduated elementary school. Suppose participants who graduated middle school, high school and college with no degree were considered medium education groups. High levels of education included bachelor’s degree, master’s degree and Ph.D. degree. Current smoking status was categorized as non-smokers and smokers. Participants were classified as married, cohabiting or single as a dichotomous variable. Family income was categorized as low, medium, and high. Information on the disease was derived from patient

records. Daily fruit and vegetable intakes were evaluated using the Food Frequency Questionnaire [4]. A fruit and vegetable intake of more than 450 gr per week per person was referred to as sufficient, and an intake of less than 450 gr per week was referred to as insufficient intake. Physical activity was assessed using the Global Physical Activity Questionnaire [13]. The physical activity and intake of fruits and vegetables were categorized as sufficient and insufficient, separately. Furthermore, we asked questions about diabetes history, diabetes duration, glycemic control, medication, insulin use and complications of diabetes.

Bodyweight, height, waist circumference, and blood pressure were measured using a standardized protocol. Body Mass Index (BMI; kg/m^2) was subsequently calculated. A semiautomatic device was used to measure blood pressure in a half-sitting position. Fasting plasma glucose (FPG) was measured by the hexokinase method, and HbA1c was measured using high-performance liquid chromatography. Total cholesterol was measured using an enzymatic colorimetric method.

2.3 Statistical analysis

The study characteristics were expressed as means with a standard deviation (SD) for normally distributed variables and as numbers with percentages in cases of categorical data. The differences between groups were compared using the Student’s *t*-test for continuous variables. The frequency distributions of categorical variables were analyzed using the Pearson Chi-Square test and general linear analyses. Furthermore, Pearson Chi-Square test and two-way ANOVA were used to compare the difference between means of MMSE according to groups such as age (<60 and ≥ 60 years of age), diabetes duration (1–5 years, 6–10, 11–15 and above 16 years), glycemic control (good and poor controlled as defined by glycated hemoglobin below and above 7.5%), presence of diabetes complications (yes/no), hypoglycemic occurrence (never, rare and regular).

Binary logistic regression analysis was performed to evaluate the association between diabetes and dementia. In univariate regression analysis, associations of age, gender, socioeconomic characteristics, and diabetic characteristics with dementia were tested. In addition, linear regression analysis was used to evaluate the associations of age with MMSE score. Furthermore, the interaction effect was tested with age in the association of diabetes with dementia. Unstandardized Beta-coefficients and Odds ratio (OR) are reported with a 95% confidence interval (CI). Analysis was adjusted for age, education, marital status and family income, diet and physical activity.

All statistical analyses were performed using IBM SPSS V.27.0 (Chicago, IL) and GraphPad Prism V.4.03 (San Diego, CA). A two-sided statistical significance was set at $P < 0.05$ for all tests.

Table 1. General characteristics of the Mongolian population.

| Characteristics | Diabetes mellitus | | P-value |
|---|-------------------|---------------|------------------|
| | DM (+) | DM (–) | |
| Age (year) | 61.3 ± 8.5 | 61.0 ± 8.7 | Matched |
| Gender: male, n (%) | 47 (35.9) | 47 (35.9) | Matched |
| Age category, n (%) | | | |
| ≤60 | 42 (32.1) | 53 (40.5) | 0.099 |
| >60 | 89 (67.9) | 78 (59.5) | |
| Education, n (%) | | | |
| Low | 26 (19.8) | 16 (12.2) | 0.411 |
| Medium | 63 (48.0) | 70 (58.0) | |
| High | 42 (32.1) | 45 (34.3) | |
| Family income: low, n (%) | 26 (19.8) | 35 (26.7) | 0.121 |
| Marital status: married, n (%) | 115 (87.8) | 111 (84.7) | 0.295 |
| Fruit and vegetable use: regular, n (%) | 35 (26.7) | 41 (31.2) | 0.260 |
| Physical activity: regular, n (%) | 18 (13.7) | 20 (15.2) | 0.464 |
| Current smokers, n (%) | 33 (25.1) | 38 (29.0) | 0.097 |
| Alcohol use, n (%) | 64 (48.9) | 53 (40.4) | 0.010 |
| BMI (kg/m ²) | 30.2 ± 5 | 29.2 ± 5.5 | 0.137 |
| Obesity, n (%) | | | 0.108 |
| Overweight (BMI 25–29.9 kg/m ²) | 48 (40.7) | 40 (38.5) | |
| Obesity (BMI >30 kg/m ²) | 57 (48.3) | 42 (40.4) | |
| Systolic BP (mm Hg) | 138.9 ± 23.4 | 133.87 ± 16.1 | 0.242 |
| Fasting glucose level (mmol/L) | 11.9 ± 5.4 | 4.9 ± 0.6 | <0.001 |
| Total cholesterol (mmol/L) | 5.2 ± 1.6 | 3.9 ± 0.4 | 0.010 |

Note: Data are presented as mean ± SD and number (percentages, %).

3. Results

3.1 General characteristics

The mean age for DM and non-DM groups was 61.3 ± 8.5 and 61.0 ± 8.7 respectively, and 35.9% were male. Age and gender were matched (Table 1). General characteristics of the DM group were low levels of education, high BMI and low fruit and vegetable intake which was statistically not significant ($P > 0.05$). Alcohol and tobacco use was relatively low in DM patients. In addition, fasting glucose level and total cholesterol findings in DM patients have statistically shown high significance ($P < 0.05$).

3.2 MMSE scores and the risk of dementia in people with and without diabetes

The distribution of the MMSE score is shown in Fig. 1. In non-diabetic subjects, the distribution was relatively normal, with a trend of frequency of participants dependently decreasing with MMSE score. The majority of patients scored more than 24 on the MMSE score. There was no similar trend in people with DM. The MMSE scores were significantly different throughout the study groups: 26.1 ± 3.7 and 27.5 ± 2.6 for people with and without diabetes, respectively. According to the domains of the MMSE, patients with diabetes have scored less on functions in registration, recall, language, three-stage command, which was statistically significant (Supplementary Table 1).

Cognitive impairment was defined as if the patients scored ≤ 24 was 29% ($n = 38$) and 11.5% ($n = 15$) in people with and

without diabetes. We compared CI and non-CI groups; education level was significant in people with and without diabetes, and age was significantly different in people without diabetes (Table 2).

MMSE was examined within the diabetic group to function diabetes duration, glycemic control, diabetic complications, and hyperglycemia. Of these measures, a longer duration of diabetes and more inadequate glycemic control were significantly associated with more unsatisfactory MMSE performance. As shown in Fig. 2, the MMSE score estimation was decreased with increasing diabetes duration, suggesting that the risk of dementia might be higher at long duration of diabetes ($P < 0.05$). The means of MMSE score were 27.0 ± 2.1 and 25.4 ± 4.2 in people who are good and poorly controlled, as defined by glycated hemoglobin ($P < 0.05$).

3.3 Dementia risk factors in people with and without diabetes

In the logistic regression analysis, older age is significantly associated with a higher risk of dementia in people without diabetes, but not in people with diabetes. In both groups of diabetic and no-diabetics, higher education level decreased the risk of dementia by an OR of 0.36 (0.20–0.64) and 0.30 (0.12–0.71) for people with and without diabetes, respectively, as compared with lower education levels (Table 3). The association between education and dementia remained significant and materially unchanged after adjusted for age in both groups. Increasing diabetes duration and a higher level of glycated hemoglobin, insulin use, hypoglycemic oc-

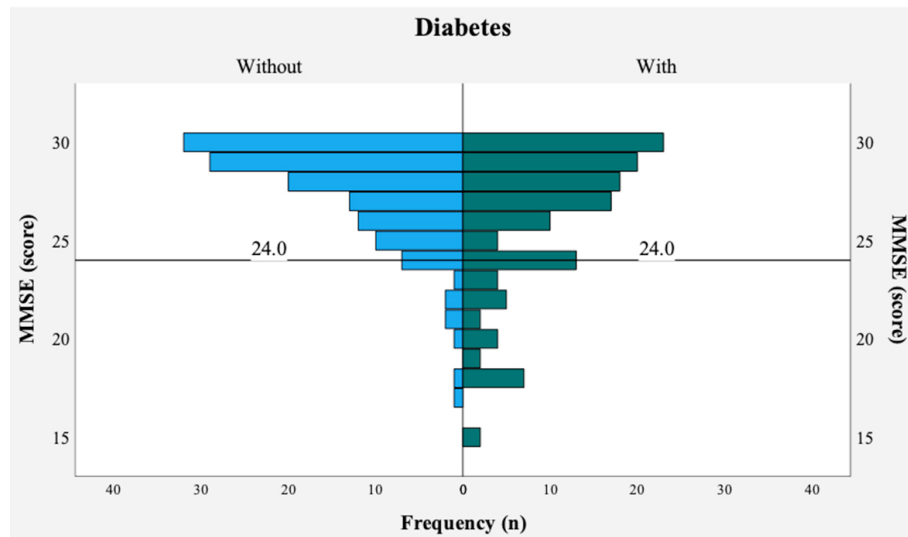


Fig. 1. Distribution of MMSE score, according to study groups. Note: MMSE, Mini mental state examination. The distribution of MMSE is shown in people with and without diabetes. Blue bars indicate MMSE in people without diabetes. Green bars indicate MMSE in people without diabetes. In non-diabetic subjects, the distribution was relatively normal, with a trend of frequency of participants dependently decreasing with MMSE score. The majority of patients scored more than 24 on the MMSE score. There was no similar trend in people with DM.

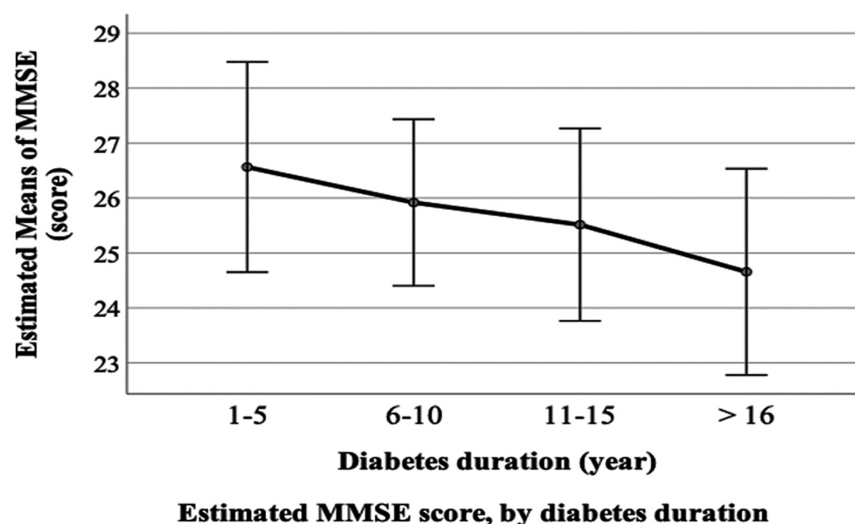


Fig. 2. Mean of MMSE score, by diabetes duration. Note: MMSE, Mini mental state examination. The chart shows association between MMSE score and diabetes duration. The MMSE score was decreased with increasing diabetes duration.

currence and the presence of diabetic complications seem to increase the risk of dementia in people with diabetes. However, those were not significant ($P > 0.05$, Table 3).

3.4 Age may not be the major emerging risk to have dementia in diabetes

Since CI is an aging-related disease, we performed stratified analyses. In the diabetic group, MMSE scores were not significantly different in middle-aged and older people, while it was significantly different in people without diabetes (Fig. 3). Therefore, we tested it using linear regression analysis between age and MMSE in age groups in diabetic and non-diabetic subjects separately.

In the linear regression analysis, age was not associated with age groups, even in older people with diabetes. This suggests that age may not be the significant risk in CI development rather than diabetes itself in people with diabetes. In contrast, age was associated with the presence of dementia in people without diabetes. Significantly, the association was stronger in older age people without diabetes. Furthermore, this was independent of gender and education (Table 4). Further association of age and MMSE was independent of other socioeconomic characteristics such as marital status, family income, smoking and alcohol, remaining materially unchanged in people without diabetes (data not shown).

Table 2. General characteristics of the Mongolian population, according to the presence of cognitive impairment.

| Findings | Cognitive impairment | | P-value |
|--|-------------------------|-------------------------|------------------|
| | Dementia (+) (MMSE ≤24) | Dementia (-) (MMSE >24) | |
| With DM (n = 131) | | | |
| Number, n (%) | 38 (29.01) | 93 (70.99) | - |
| Mean age ± SD, year | 62.5 ± 7.4 | 60.9 ± 9.0 | 0.295 |
| Sex: male, n (%) | 12 (31.6) | 35 (37.6) | 0.327 |
| Education: lower level, n (%) | 14 (36.8) | 12 (12.9) | 0.001 |
| Mean BMI ± SD, kg/m ² | 29.9 ± 5.0 | 30.4 ± 5.0 | 0.623 |
| Normal weight, n (%) | 6 (16.2) | 7 (8.6) | 0.735 |
| Fruit and vegetable intake: regular, n (%) | 10 (26.3) | 25 (26.8) | 0.572 |
| Physical activity: regular, n (%) | 5 (13.1) | 13 (14.9) | 0.586 |
| Mean systolic BP ± SD, mm Hg | 140.1 ± 19.7 | 138.1 ± 26.4 | 0.796 |
| Smoking: smokers, n (%) | 9 (23.7) | 24 (25.8) | 0.150 |
| Alcohol use, n (%) | 20 (52.6) | 44 (47.3) | 0.320 |
| Diabetes duration ± SD, year | 11.2 ± 5.8 | 10.4 ± 6.8 | 0.358 |
| Glycated hemoglobin ± SD, % | 10.3 ± 2.8 | 10.1 ± 2.5 | 0.180 |
| Total cholesterol (mmol/L) | 5.6 ± 2.1 | 4.9 ± 1.2 | 0.174 |
| Diabetic complication, n (%) | 14 (51.9) | 31 (33.3) | 0.440 |
| Without DM (n = 131) | | | |
| Number, n (%) | 15 (11.45) | 116 (88.55) | - |
| Mean age ± SD, year | 71.2 ± 8.0 | 59.7 ± 7.9 | <0.001 |
| Sex: male, n (%) | 6 (40.0) | 41 (35.3) | 0.465 |
| Education: lower level, n (%) | 2 (13.3) | 14 (12.0) | 0.628 |
| Mean BMI ± SD, kg/m ² | 28.4 ± 7.1 | 29.2 ± 5.3 | 0.728 |
| Normal weight, n (%) | 3 (30.0) | 19 (20.0) | 0.474 |
| Fruit and vegetable intake: regular, n (%) | 3 (20.0) | 38 (32.7) | 0.232 |
| Physical activity: regular, n (%) | 1 (6.7) | 19 (16.3) | 0.311 |
| Mean systolic BP ± SD, mm Hg | 129.2 ± 20.8 | 134.1 ± 16.0 | 0.629 |
| Smoking: smokers, n (%) | 7 (46.7) | 31 (26.7) | 0.090 |
| Alcohol use, n (%) | 8 (53.3) | 45 (38.8) | 0.097 |
| Total cholesterol (mmol/L) | 4.3 ± 0.9 | 3.8 ± 0.8 | 0.401 |

Note: Data are presented as mean \pm SD and number (percentages, %).

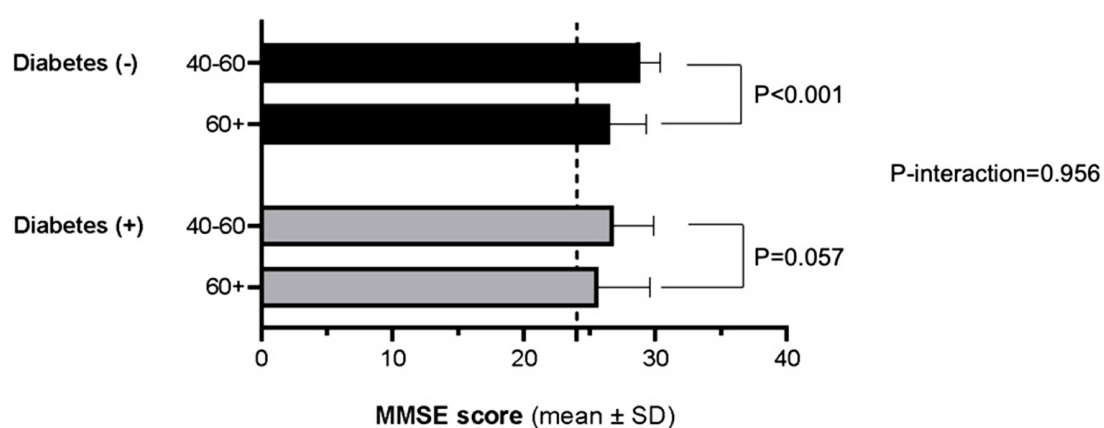


Fig. 3. Mean of MMSE, according to age and diabetes status. Note: MMSE, Mini-mental state examination. The mean score of MMSE is shown in people with and without diabetes according to age group. According to age groups, black and grey bars indicate mean MMSE scores in people without/with diabetes respectively. The mean MMSE score in older people (60 years and older) was significantly lower than younger people (40–60 years) regardless of diabetes. MMSE score tends to be lower in people with diabetes. The interaction for the association between age and MMSE score through diabetes was not significant.

Table 3. Association of risk factors with cognitive impairment, diabetes status.

| Variables | Risk of dementia (MMSE \leq 24) | | | |
|--------------------------------|-----------------------------------|--------------|------------------|------------------|
| | With diabetes | | Without diabetes | |
| | OR (95% CI) | P-value | OR (95% CI) | P-value |
| Age (year) | 1.02 (0.97–1.07) | 0.330 | 1.22 (1.11–1.35) | <0.001 |
| Gender (male/female) | 1.30 (0.58–2.91) | 0.513 | 0.82 (0.27–2.4) | 0.724 |
| Education (higher/lower) | 0.36 (0.20–0.64) | 0.001 | 0.30 (0.12–0.71) | 0.006 |
| BMI (overweight/normal) | 2.04 (0.63–6.58) | 0.230 | 1.69 (0.40–7.16) | 0.475 |
| Hypertension (No/Yes) | 2.00 (0.79–5.08) | 0.142 | 2.15 (0.64–7.17) | 0.210 |
| Smoking (No/Yes) | 0.89 (0.37–2.15) | 0.800 | 2.39 (0.80–7.16) | 0.117 |
| Alcohol use (No/Yes) | 1.23 (0.58–2.63) | 0.581 | 1.80 (0.61–5.31) | 0.285 |
| Total cholesterol (mmol/L) | 1.15 (0.51–2.70) | 0.711 | 1.01 (0.48–6.89) | 0.495 |
| Diabetes duration (year) | 1.01 (0.94–1.09) | 0.637 | - | - |
| Glycated hemoglobin (%) | 1.02 (0.86–1.22) | 0.752 | - | - |
| Insulin use (No/Yes) | 1.48 (0.61–3.61) | 0.380 | - | - |
| Hypoglycemia (none/regular) | 1.49 (0.59–3.78) | 0.392 | - | - |
| Diabetes complication (No/Yes) | 1.19 (0.47–3.02) | 0.700 | - | - |

Note: Data are expressed with odds ratio and 95% CI. Each categorical determinant variable consisted of two categories in the binary regression analysis.

Table 4. Association of age and cognitive impairment.

| Age (y) | Unstandardized β coefficients MMSE | | | | | |
|----------------------|--|------------------|-----------------------------|------------------|--|------------------|
| | Crude | | Adjusted for age and gender | | Adjusted for age, gender and education | |
| | B (95% CI) | P-value | B (95% CI) | P-value | B (95% CI) | P-value |
| With diabetes | | | | | | |
| 40–60 y (n = 42) | –0.07 (–0.23; –0.09) | 0.376 | –0.06 (–0.23; –0.11) | 0.484 | –0.09 (–0.28; –0.08) | 0.280 |
| \geq 60 y (n = 89) | –0.04 (–0.20; –0.11) | 0.591 | –0.04 (–0.20; 0.11) | 0.563 | –0.00 (–0.14; –0.15) | 0.953 |
| Without diabetes | | | | | | |
| 40–60 y (n = 53) | –0.10 (–0.18; –0.02) | 0.009 | –0.10 (–0.18; –0.02) | 0.009 | –0.11 (–0.18; –0.03) | 0.006 |
| \geq 60 y (n = 78) | –0.20 (–0.30; –0.09) | <0.001 | –0.20 (–0.31; –0.09) | <0.001 | –0.20 (–0.30; –0.10) | <0.001 |

Note: Data are expressed with odds ratio and 95% CI. Age was used continuous variable in the linear regression analysis.

4. Discussion

This study found that MMSE scores are significantly lower in people with diabetes than those without diabetes, independent of age. This suggests that people of any age with diabetes may have a higher risk of vascular dementia. In contrast, it seems that aging plays a significant role in the development of cognitive impairment in people without diabetes. This association was also independent of gender and socioeconomic factors such as education, marital status, family income, smoking and alcohol. Although diabetes duration and diabetes control with dementia were not significant, more unsatisfactory MMSE performance was related to longer diabetes duration and more insufficient diabetes control ($P < 0.05$) in the diabetic group. This suggests that diabetes duration and diabetes control can impact cognitive performance in people with diabetes. Further studies are needed to thoroughly investigate the predictors of cognitive impairment of people with diabetes in Mongolia.

Previous works found a statistically significant difference in the average score of MMSE in people with and without diabetes [14, 15]. People of any age with diabetes may have a higher risk of cognitive impairment [16]. The mean MMSE

scores of people with and without diabetes were 28.25 ± 2.38 and 26.07 ± 2.6 [16] whereas 26.1 ± 3.7 and 27.5 ± 2.6 for people with and without diabetes in our study. Generally, about 20% of people with diabetes have a cognitive impairment, compared to 5 to 10% of the general population [15, 17].

Furthermore, it is estimated that about 15% of cognitive impairment develops dementia in people with diabetes [14, 18]. In a 4-year follow-up work [19], patients with type 2 diabetes showed moderate decrements in information processing speed (decreased by -0.37) and attention and executive function (decreased by -0.25) compared with the control group. Therefore, clinical guidelines and recommendations state that it is crucial to assess cognitive function annually in people with diabetes [8, 10]. However, in our country, it has not yet been introduced to diabetes management.

The previous studies for risk of developing cognitive impairment have demonstrated that diabetes duration, diabetes control, HbA1c, insulin treatment, hypoglycemia recurrence are the main risk factors [20]. For instance, in Poland, insulin treatment is one of the risks contributing to cognitive impairment [21]. These risk factors in DM and non-DM subjects

were different in descriptive analysis, however statistically not significant. For instance, HbA1c level was slightly high in people with dementia. This insignificance might be related to the poor glucose control, high levels of average HbA1c of the DM patients in Mongolia. Diabetes duration was not significantly different in people with and without dementia; however, the MMSE score tends to be dropping while the duration of diabetes increases. The risks of developing CI in DM patients, such as insulin treatment and hypoglycemia recurrence, were not observed. This might be explained by the limitations of the study design, which suggests that further investigations need to be done by using other study designs that allow for more participants.

In Mongolia, the work investigating the prevalence of cognitive impairment in <55 year-old in the general population showed that 39.7% has cognitive impairment [22]. Cognitive impairment is the most common condition in older adults. However, cognitive decline—including dementia—can also occur in middle-aged people [23]. Especially in developing countries, the prevalence of early-onset dementia is increasing. According to the WHO, 9% of people under age 60 develop cognitive impairment [23]. Most cases are due to aging, but other causative cognitive declines, including vascular cognitive impairment [9]. Our findings show that the cognitive impairment in people without diabetes seems to be associated with age, while the leading cause in people with diabetes is not only because of age but also from diabetes. In our work, cognitive impairment in people without diabetes was 11.5%, compared to 29% in people with diabetes. This suggests that vascular cognitive impairment might be a common underlying cause of dementia in people with diabetes in Mongolia. Therefore, it reveals the need for further investigations, especially on vascular dementia, to fully elucidate the risk and association with diabetes and early prevention measurement.

We have shown that among the education level contributes considerably to the development of cognitive impairment among socio-economic factors. MMSE score tends to decrease along with the education level in both groups, which was statistically significant. The association between cognitive impairment and socioeconomic factors such as education is not studied in Mongolia yet. It demonstrates this kind of disciplinary research is much needed. Several studies have demonstrated a high association between higher levels of education and the prevalence of dementia in developing countries [14, 15]. At the same time, these studies reveal that intellectual exercise and training are crucial to prevent cognitive impairment in the general population [16, 19].

The main strength is that it is the first study to explore the association between diabetes and cognitive impairment in Mongolia. We assume that the current study compares the people with and without diabetes with dementia. Its association with age would be a base data to define the other risk factors, not only age for CI. However, there are some limitations. We have not used other cognitive tests such as

CERAD; however, the method we used in most of these studies allows us to compare the results of previous studies. Finally, the study design was cross-sectional.

5. Conclusions

We found that dementia was independent of age in people with diabetes, suggesting that people of any age with diabetes may have a higher risk of vascular dementia, considering the microcapillary pathology resulting from chronic diabetes. In contrast, it seems that aging does play a significant role in the development of cognitive impairment in people without diabetes. Furthermore, diabetes duration and diabetes control are associated with cognitive impairment in people with diabetes. However, since MMSE is sensitive to dementia and not specific to vascular dementia, further studies involving neuroimaging and neurological examination are needed to fully elucidate the problem of a link between type 2 diabetes in Mongolia and vascular dementia in a Mongolian population.

Abbreviations

ANOVA, Analysis of Variance; BMI, Body Mass Index; CI, Confidence Interval; CI, Cognitive Impairment; MMSE, Mini-Mental State Examination; OR, Odds Ratio; SD, Standard Deviation.

Author contributions

OB, BD, MM and DN conceived and designed the study. MM, DN, PB and EA collected data. MM, OB, DN, EA and PB analyzed the data. BD, OB, MM and DN wrote the paper. SJ, BD and OB reviewed and edited the paper.

Ethics approval and consent to participate

The Medical Ethical Committee of the Mongolian National University of Medical Sciences approved the research plan at hand, code METc 2020/3-05. All participants gave written informed consent.

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Conflict of interest

The authors declare no conflict of interest.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at <https://doi.org/10.31083/j.jin2003070>.

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