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Factors associated with social isolation and being homebound among older patients with diabetes: a cross-sectional study

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ABSTRACT

Objective We aimed at investigating factors associated with social isolation and being homebound in older patients with diabetes.

Design Cross-sectional study.

Settings Those undergoing outpatient treatments at Ise Red Cross Hospital, Mie Prefecture.

Participants Patients with diabetes aged ≥65 years.

Primary and secondary outcome measures Social isolation was defined as indulging in less than one interaction per week with individuals other than cohabiting family members. We defined homebound as going outside home less than once a day. To identify factors associated with social isolation and being homebound, we performed logistic regression analysis. The dependent variable was social isolation or homebound and independent variables were basic attributes, glycaemic parameters, complications and treatment details.

Results We analysed 558 cases (320 men and 238 women). Among these, 174 (31.2%) were socially isolated; meanwhile, 87 (15.6%) were homebound. The glycoalbumin/haemoglobin A1c ratio (OR 4.52; 95% CI 1.07 to 19.1; p=0.040) and the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC) scores (OR 0.72; 95% CI 0.57 to 0.90; p=0.006) had significant associations with social isolation. TMIG-IC scores (OR 0.78; 95% CI 0.66 to 0.92; p=0.003) and insulin use (OR 4.29; 95% CI 1.14 to 16.1; p=0.031) were associated with being homebound.

Conclusion In older patients with diabetes, glycaemic fluctuations and insulin use are associated with social isolation and being homebound, respectively. In addition, a decline in higher level functional capacity is a common factor associated with social isolation and being homebound. Thus, it is important to pay attention to social isolation and being homebound when a decline in higher level functional capacity, increased glycaemic fluctuations and insulin use in older patients with diabetes are observed.

Strengths and limitations of this study

- The validity of definitions of social isolation and being homebound used in our study has been established in the previous studies.
- We performed data analyses based on demographic characteristics, results of laboratory tests conducted in routine medical practice and medical interviews.
- The patients were outpatients at a clinic specialising in diabetes, and many of them had severe symptoms; therefore, the results of this study may not be applicable to patients with mild or stable diabetes who were treated by their primary physicians.
- This study did not include a measure of health, education history or income, which can affect the results.
- This is a cross-sectional study, so it is difficult to make statements regarding causality.

BACKGROUND

The older population is growing globally, and Japan houses one of the greatest populations in this age group.[1 2] Age-related changes include a decline in physical and mental functions and the risk of decreased social interaction.[3 4] The opportunities for interacting with others[3] or going out less frequently[5] decrease with age. If a person is homebound or socially isolated, such opportunities are limited. Social isolation can be defined as a state in which the frequency of interactions with others is reduced to a frequency of less than once a week. It is usually associated with loss of cognitive functions, low quality of life (QOL) and increased mortality.[6–9] Being homebound can be defined as a state in which the frequency of leaving home is extremely low. It is usually associated with a deterioration of physical function, activities of daily living (ADLs) and higher mortality.[8 10–13] Previous studies involving community-dwelling older patients revealed that the frequency of social isolation and being homebound is 22.3%–30.2% and 23.7%–29.5%, respectively.[10 14] It has become

increasingly important to evaluate health status in older individuals through focusing on how they interact with the community and the greater society.[8 14] Therefore, social isolation and being homebound is an extremely critical issue in an ageing society.

Previous community studies involving the older have reported factors associated with social isolation and being homebound. These include male sex,[3 15] decline in higher level functional capacity and depression.[3 16] In addition, depression and deterioration of higher level functional capacity are factors associated with being homebound.[17 18] However, these were community studies with older people, with no reports among older population with diabetes. Older patients with diabetes usually have diabetic complications such as diabetic retinopathy, diabetic neuropathy and/or diabetic nephropathy that frequently require pharmacotherapies including insulin, to maintain good glycaemic control. In addition, such patients often experience a decline in mental and physical functions, which may increase the risk of decreased social interaction. Their awareness of the need to maintain good glycaemic control and their attitudes towards the requirement of pharmacotherapy outside home may contribute to their decreased interaction with others and low frequency of leaving home.[19 20]

Therefore, we hypothesised that in addition to the previously reported decline in physical and mental function, poor glycaemic parameters, diabetic complications and treatment of diabetes could be factors associated with social isolation and being homebound in older patients with diabetes. We believe that calling attention to these relationships will increase physicians' awareness on the importance of taking precautions to prevent social isolation and homeboundness in older patients with diabetes with poor glycaemic control and complications. Hence, we aimed at identifying factors associated with social isolation and being homebound (including glycaemic parameters, diabetic complications and treatment for diabetes) in older patients with diabetes.

METHODS

Study design and population

We underwent a cross-sectional study with patients with diabetes undergoing outpatient treatment at Ise Red Cross Hospital in Ise City, Mie Prefecture.

Eligibility criteria included patients with diabetes ≥65 years who visited the outpatient clinic between June 2017 and August 2019.

Exclusion criteria included the following: alcohol addiction, severe psychiatric disorders, history of malignant tumours, having an implanted pacemaker, past bilateral knee or hip replacement, undergoing home oxygen therapy, diagnosis of heart failure within the past 6 months or inability to cooperate with the study independently.

Evaluation of social isolation and homebound

Social isolation and being homebound were defined similar to previous large cohort community studies involving older patients in Japan.[10 14] We asked patients a question regarding interpersonal interaction, 'How often do you see someone including your family members who are not living with you, your friends or your neighbours?', and a question regarding non-interpersonal contact, 'How often do you communicate with your family members not living with you, your friends or your neighbours?' We instructed the patients to answer as 'less than once a week' or 'at least once a week'. We defined social isolation as an answer of 'less than once a week' for both questions.[8 14]

Furthermore, we instructed the patients to answer the question 'How often do you go out?' as 'less than once a day' or 'at least once a day'. Hence, we defined being homebound as an answer of 'less than once a day' for this question.[8 14]

Clinical variables

We surveyed the following parameters: age, sex, body mass index, (weight (kg)/height(m^2)), smoking and drinking habits, classification of diabetes (type 1, type 2 or other), duration of diabetes, haemoglobin A1c (HbA1c), glycoalbumin (GA)/HbA1c ratio, hypertension, dyslipidaemia, diabetic retinopathy, diabetic neuropathy, diabetic nephropathy, cardiovascular diseases and use of diabetic drugs.

Classification of diabetes into type 1, type 2 and other was done according to the diagnostic criteria of the Japanese Diabetes Society.[21] Diabetes was diagnosed as blood glucose levels (a fasting blood glucose level ≥126 mg/dL, a random blood glucose level ≥200 mg/dL or a blood glucose level on a 2 hour oral glucose-tolerance test ≥200 mg/dL, whichever was met) and HbA1c ≥6.5%. We evaluated the GA/HbA1c ratio (a glycaemic control index) in addition to HbA1c. HbA1c is an index that indicates the mean blood glucose, while the GA/HbA1c ratio is an index that reflects the status of hyperglycaemic after meals.[22] Some studies suggested that the GA/HbA1c ratio and HbA1c are independent factors associated with the onset of diabetes-related complications and cognitive impairment.[23 24] Thus, we measured these values in our study. In addition, we measured systolic and diastolic pressures in the examination room. Systolic pressure ≥130 mm Hg, and/or diastolic pressures ≥80 mm Hg and/or taking oral antihypertensive agents was considered as hypertension. Furthermore, if any of the following was observed, the patient was considered to have dyslipidaemia: es≥150 mg/dL, high-density lipoprotein-cholesterol <40 mg/dL or low-density lipoprotein-cholesterol (LDLC) of ≥120 mg/dL (in patients with coronary artery disease, an LDLC ≥100 mg/dL) or taking oral lipid-lowering drugs.

An ophthalmologist confirmed the presence or absence of a diabetic retinopathy. We considered diabetic neuropathy if reduced Achilles tendon reflex, decreased vibration sensation on the lateral malleolus and/or an

abnormal nerve conduction test was present. We considered coronary artery disease when the patient had either a present diagnosis or history of ischaemic heart disease (such as angina pectoris, myocardial infarction). We also reviewed the presence or absence of cerebrovascular diseases such as cerebral infarction.

Questionnaire survey

We investigated the following factors related to social isolation and being homebound in older individuals based on previous community studies: higher level functional capacity, cognitive function, depression, sleep disorders and living alone.[3 11 15 25] We used the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC),[26] (a self-administered questionnaire containing 13 items), to evaluate higher level functional capacity. The TMIG-IC is widely used in Japan for evaluating higher level functional capacity, and its reliability and validity are tested and proven.[26] Five questions are related to the instrumental ADLs (such as meal preparation, financial management and the use of transportation), four are related to intellectual activities and four are related to social roles. The questionnaire uses two multiple-choice questions with yes/no options. The score varies from 0 to 13 points, with a higher score indicating better higher level functional capacity.

To measure cognitive function, we used the Japanese version of Test Your Memory (TYM-J); a validated self-administered, cognitive function evaluation tool developed by Hanyu *et al*.[27] It comprises orientation (10 points), ability to copy a sentence (two points), knowledge (three points), calculation (four points), verbal fluency (four points), similarities (four points), naming (five points), visuospatial/constructive functions (two tasks, seven points), recall of a sentence (six points) and help (five points). The total score ranges from 0 to 50 points, and a lower score indicates lower cognitive function. In this study, a TYM-J total score of ≤44 was considered to represent cognitive dysfunction.

To measure depression, we used the Japanese version of the Patient Health Questionnaire 9 (J-PHQ-9); a 9-item validated questionnaire developed by Muramatsu *et al*.[28] It is a 4-point scale questionnaire (almost everyday, 3 points; more than half the days, 2 points; several days, 1 point; not at all, 0 points) about symptoms in the past 2 weeks. The total score ranges from 0 to 27 points, and a higher score indicates a greater degree of depression. In this study, we considered a J-PHQ-9 score of ≥5 to indicate depression similar to previous studies.[28]

We used the Japanese version of the Pittsburgh Sleep Quality Index (PSQI-J)[29] to measure sleep disorders. The PSQI-J is a self-administered questionnaire that is widely used for sleep disorder evaluation. The questionnaire comprises of the following seven components: sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication and daytime dysfunction. Each component is scored on a 0–3 point scale, with a total score ranging from 0 to 21 points; a higher score indicates a lower quality of sleep. This score is a highly reliable and valid scale that provides quantitative and qualitative information on sleep and enables comparison between individuals and groups. We considered a total score of ≥5.5 points as a sleep disorder based on the previous studies.[29]

Statistical analysis

The patient characteristics were described according to the presence or absence of social isolation and being homebound. We used unpaired t-test for continuous variables and χ^2 test for binary variables of group comparisons.

To identify factors associated with social isolation and being homebound, we analysed data in the following manner. First, we performed univariate analysis using logistic regression model with social isolation and being homebound as dependent variables. Our explanatory variables included age, sex, HbA1c, GA/HbA1c ratio, hypertension, dyslipidaemia, diabetic retinopathy, diabetic neuropathy, diabetic nephropathy, cardiovascular diseases, depression, sleep disorders, decline in cognitive function, TMIG-IC score, living alone, use of oral hypoglycemic agents and the use of insulin, selected based on prior studies,[3 15 17 18] and clinical judgement. Thereafter, we performed multivariate analysis using statistically significant variables (significance level $p<0.05$ for both sides) obtained from the univariate analysis to identify factors associated with social isolation and being homebound.

We performed data analyses using STATA V.16.0 (Stata Corporation LP, College Station, Texas, USA).

Patient and public involvement statement

The patients and public were not involved in this research.

RESULTS

We enrolled 602 patients following our eligibility criteria. Among these, we excluded 44 due to missing data and included 558 (320 men and 238 women) for the study.

Table 1 shows the baseline characteristics. We observed 174 (31.2%) patients with social isolation and 87 (15.6%) who were homebound. The mean age was 72 years old, the mean duration of diabetes was 18 years, and the mean HbA1c was 7.3%. Seventy-eight per cent used oral hypoglycemic agents and 68% used insulin. The social isolation group was older (73.6 years vs 72.1 years) and had higher GA/HbA1c ratios (2.9 vs 2.6), lower TMIG-IC scores (9.5 points vs 11.6 points) and higher frequency of diabetic neuropathy (77.9% vs 62.9%) and sleep disorders (78.1% vs 69.7%) than the non-social isolation group. The homebound group was also older (75.4 years vs 72.1 years) with higher frequencies of diabetic neuropathy (85.7% vs 63.9 %), cardiovascular disease (42.3% vs 21.2 %), depression (72.1% vs 56.9 %) and the use of insulin (85% vs 63 %), but a lower TMIG-IC score (8.4 points vs 11.4 points) than the non-homebound group.

Table 1 Characteristics of the analysis population

	Non-social isolation n=384 (68.8%)	Social isolation n=174 (31.2%)	P value	Non homebound n=471 (84.4%)	Homebound n=87 (15.6%)	P value
Age (years), mean (SD)	72.1 (6.6)	73.6 (6)	0.009*	72.1 (6.3)	75.4 (6.5)	<0.001*
Male, %	73.6	63.2	0.481	74.5	48.2	0.722
BMI (kg/m^2), mean (SD)	24.3 (4.5)	24 (4.3)	0.722	24.1 (4.5)	24.8 (4.3)	0.264
T1DM/T2DM/others, %	7.8/91/1.2	5.5/92.7/1.8	0.635	7.6/91.5/0.9	5/91.7/3.3	0.268
Duration of diabetes (years), mean (SD)	16.6 (10.5)	20.6 (11.4)	0.001*	17.2 (10.7)	21 (11.8)	0.017*
HbA1c (%), mean (SD)	7.2 (1)	7.4 (1.1)	0.213	7.3 (1)	7.2 (1.1)	0.374
GA/HbA1c, mean (SD)	2.6 (0.3)	2.9 (0.6)	0.002*	2.7 (0.4)	2.8 (0.4)	0.091
Alcohol consumption, %	19	22.6	0.491	20.7	16.6	0.521
Smoking, %	21.6	28.5	0.201	25.5	12.5	0.050
Hypertension, %	76.8	85.3	0.066	78.2	85	0.235
Dyslipidaemia, %	70.5	76.1	0.274	70.7	80	0.141
Retinopathy, %	39.6	42.5	0.629	39.7	44.2	0.549
Neuropathy, %	62.9	77.9	0.021*	63.9	85.7	0.006*
Nephropathy, %	55.1	63.2	0.183	56.8	61.4	0.071
Cardiovascular disease, %	22.3	30.1	0.117	21.2	42.3	0.001*
Depression, %	56.9	65.1	0.136	56.9	72.1	0.027*
Sleep disorder, %	69.7	78.1	0.040*	71.1	79.3	0.117
Cognitive impairment, %	13.8	12	0.576	12.1	19.5	0.060
TMIG-IC (points), mean (SD)	11.6 (2.1)	9.5 (3.3)	<0.001*	11.4 (2.3)	8.4 (3.5)	<0.001*
Living alone, %	15	17.4	0.306	15.4	17.4	0.067
Oral hypoglycemic agents, %	78.8	77.9	0.859	78.9	76.6	0.695
GLP-1 analogue, %	12.3	10	0.542	11	15	0.381
Insulin, %	63.8	73.3	0.074	63	85	0.001*

*p < 0.05.
BMI, body mass index; GA, glycoalbumin; GLP-1, glucagon-like peptide-1; HbA1c, haemoglobin A1c; T1DM/T2DM, type 1/type 2 diabetes mellitus; TMIG-IC, Tokyo Metropolitan Institute of Gerontology Index of Competence.

Table 2 shows the results of the logistic regression analysis. Age, GA/HbA1c ratio, diabetic neuropathy, sleep disorder, TMIG-IC scores and being homebound were significantly present in socially isolated cases. Then, we assessed the items using multivariate analysis. Only GA/HbA1c ratios (OR 4.52; 95% CI 1.07 to 19.1; p=0.040) and TMIG-IC scores (OR 0.72; 95% CI 0.57 to 0.90; p=0.006) were associated with social isolation on multivariate analysis. Age, diabetic neuropathy, cardiovascular disease, depression, TMIG-IC scores, the use of insulin and social isolation were significantly present in homebound cases. However, only TMIG-IC scores (OR 0.78; 95% CI 0.66 to 0.92; p=0.003) and the use of insulin (OR 4.29; 95% CI 1.14 to 16.1; p=0.031) were significantly associated with being homebound on multivariate analysis.

Although univariate analysis did not show an association between social isolation and a cognitive impairment, cognitive impairment could be a confounding factor in the association between social isolation and glycaemic fluctuation. For that reason, we introduced cognitive impairment into the multivariate analysis, and we performed an additional analysis. Results showed that even after adjustment for cognitive impairment, there was a significant association between social isolation and GA/HbA1c ratios (4.73 (95% CI 1.11 to 20.10; p=0.035)).

DISCUSSION

In this exploratory study, we examined factors associated with social isolation and being homebound in older patients with diabetes. Glycaemic fluctuations and the use of insulin were identified as factors associated with social isolation and being homebound, respectively. In addition, a decline in higher level functional capacity was identified as a common factor associated with both social isolation and being homebound.

First, we examined the frequency of social isolation and being homebound. In previous community studies

Table 2 Multiple regression with social isolation and homebound as the outcome

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	P value	OR (95% CI)	P value
Social isolation				
Age, per year increase	1.04 (1.01 to 1.07)	0.009*	1.04 (0.94 to 1.15)	0.436
Male (vs women)	0.98 (0.91 to 1.06)	0.722		
HbA1c, per 1% increase	1.11 (0.93 to 1.32)	0.214		
GA/HbA1c, per one increase	2.79 (1.36 to 5.73)	0.005*	4.52 (1.07 to 19.1)	0.040*
Alcohol consumption (vs no)	1.24 (0.67 to 2.29)	0.491		
Smoking (vs no)	1.45 (0.81 to 2.56)	0.202		
Hypertension (vs no)	1.74 (0.95 to 3.19)	0.068		
Dyslipidaemia (vs no)	1.33 (0.79 to 2.22)	0.275		
Retinopathy (vs no)	1.12 (0.69 to 1.82)	0.629		
Neuropathy (vs no)	2.07 (1.11 to 3.88)	0.022*	0.61 (0.18 to 2.06)	0.426
Nephropathy (vs no)	1.36 (0.87 to 2.13)	0.175		
Cardiovascular disease (vs no)	1.49 (0.90 to 2.48)	0.118		
Depression (vs no)	1.41 (0.89 to 2.22)	0.137		
Sleep disorder (vs no)	1.54 (1.01 to 2.35)	0.041*	1.18 (0.39 to 3.49)	0.765
Cognitive impairment (vs no)	0.85 (0.49 to 1.47)	0.576		
TMIG-IC, per one point increase	0.74 (0.68 to 0.8)	<0.001*	0.72 (0.57 to 0.90)	0.006*
Living alone (vs no)	1.18 (0.73 to 1.91)	0.480		
Oral hypoglycemic agents (vs no)	0.95 (0.55 to 1.63)	0.859		
Insulin (vs no)	1.56 (0.95 to 2.56)	0.075		
Homebound (vs no)	4.25 (2.64 to 6.83)	<0.001*	1.11 (0.19 to 6.26)	0.902
Homebound				
Age, per year increase	1.09 (1.05 to 1.13)	<0.001*	1.01 (0.93 to 1.09)	0.740
Male (vs women)	0.64 (0.4 to 1.02)	0.061		
HbA1c, per 1% increase	0.9 (0.71 to 1.13)	0.373		
GA/HbA1c, per one increase	1.41 (0.75 to 2.66)	0.277		
Alcohol consumption (vs no)	0.76 (0.33 to 1.73)	0.522		
Smoking (vs no)	0.41 (0.16 to 1.01)	0.056		
Hypertension (vs no)	1.57 (0.79 to 3.36)	0.239		
Dyslipidaemia (vs no)	1.65 (0.84 to 3.26)	0.144		
Retinopathy (vs no)	1.20 (0.66 to 2.18)	0.549		
Neuropathy (vs no)	3.38 (1.35 to 8.41)	0.008*	1.79 (0.52 to 6.13)	0.349
Nephropathy (vs no)	1.19 (0.68 to 2.07)	0.534		
Cardiovascular disease (vs no)	2.72 (1.51 to 4.89)	0.001*	1.41 (0.55 to 3.59)	0.463
Depression (vs no)	1.95 (1.07 to 3.56)	0.029*	2.18 (0.86 to 5.50)	0.096
Sleep disorder (vs no)	1.55 (0.89 to 2.71)	0.119		
Cognitive impairment (vs no)	1.76 (0.97 to 3.2)	0.063		
TMIG-IC, per one point increase	0.72 (0.6 5 to 0.78)	<0.001*	0.78 (0.66 to 0.92)	0.003*
Living alone (vs no)	1.14 (0.62 to 2.09)	0.652		
Oral hypoglycemic agents (vs no)	0.87 (0.45 to 1.69)	0.695		
Insulin (vs no)	3.31 (1.57 to 6.97)	0.002*	4.29 (1.14 to 16.1)	0.031*
Social isolation (vs no)	4.25 (2.64 to 6.83)	<0.001*	1.60 (0.64 to 3.99)	0.312

*p < 0.05.
GA, glycoalbumin; HbA1c, haemoglobin A1c; TMIG-IC, Tokyo Metropolitan Institute of Gerontology Index of Competence.

on the older with similar definitions to our study, the frequency of social isolation and being homebound was 22.3%–30.2% and 23.7%–29.5%, respectively.[10 14] In our study, the frequency of social isolation was 31.2%, which is slightly higher than that reported in the previous studies. Compared with those studies,[10 14] the patients in our study had a significantly greater decline in higher level functional capacity including instrumental ADLs. They also had more comorbidities such as cardiovascular disease and depression. In addition, many patients in our study had diabetes complications such as retinopathy, neuropathy and nephropathy. A decline in higher level functional capacity and multiple comorbidities is thought to be associated with social isolation,[3] which may explain the increase in the number of patients with social isolation in our study. However, in our study, the frequency of being homebound was lower than that reported in the previous studies.[10 14] The patients in our study were outpatients with expected normal ADL, and this may not have hindered their going out. Furthermore, the percentage of men in our study was higher than that reported in the previous studies. Generally, the frequency of being homebound in men is lower than in women,[10 14] which could be the reason for the low frequency of being homebound in our study.

Next, we discuss the association between glycaemic fluctuation and social isolation. To the best of our knowledge, this is the first study to demonstrate an association between social isolation and glycaemic fluctuation. Kinoshita *et al*[24] and Mukai *et al*[30] have reported that glycaemic fluctuations assessed by GA/HbA1c are associated with a decrease in cognitive function. The average or cut-off value of GA/HbA1c in these studies in the cognitive decline group was 2.7–2.8.[24 30] GA/HbA1c in the social isolation group in our study was 2.9, indicating a large fluctuation similar to that reported in the previous studies. Although, in our study, univariate analysis did not show an association between social isolation and decline in cognitive function, cognitive function decline could be a confounding factor in the association between social isolation and glycaemic fluctuation. Hence, we introduced cognitive function decline into the multivariate analysis and we performed an additional analysis. Thus, after adjustment for cognitive function decline, we observed a significant association between social isolation and GA/HbA1c (4.73, 95% CI 1.11 to 20.10; p=0.035). This suggests that there may be another mechanism other than cognitive decline in the association between social isolation and glycaemic fluctuation. This could be explained by the fact that patients with diabetes are psychologically prone to avoid interactions with others due to their status.[19 20] This involves self-stigma, negative thoughts about themselves or agreement with a negative emotional reaction or opinion of others.[19 20] The mean GA/HbA1c ratio in the social isolation group in this study was comparable to levels of glycaemic fluctuation suggested to be associated with vascular complications in the previous studies.[24 30] In addition, our patients suffered from diabetes for a long time, many of them used insulin, thus their frequency of postprandial hyperglycaemic and hypoglycaemic was estimated to be high. It is possible that the patients were psychologically prone to avoid interaction with others due to their conditions. Moreover, increased glycaemic fluctuations are reported to be associated with fear of having hypoglycaemic and psychological burden.[31 32] These aspects may also decrease interaction with others. In contrast, there was no association between social isolation and HbA1c. The mean HbA1c in this study was 7.3%, suggesting that glycaemic control was relatively stable considering that the subjects of this study were older patients with diabetes. Thus, the stable blood glucose levels of the patients may explain the minor impact of HbA1c the index of the mean blood glucose, on social isolation.

Next, we discuss the association between use of insulin and being homebound. To the best of our knowledge, this is the first study to demonstrate an association between being homebound and the use of insulin. Although we observed an association between being homebound and the use of insulin in our study, the reason was unclear. Previous studies have reported that diabetes patients on insulin do not want others to know about it. Therefore, they tend to avoid interacting with others.[19 20] In addition, older diabetes patients on insulin have a high risk of hypoglycaemic.[33] Therefore, they are usually anxious about this.[34] Although it is only speculative, this psychological feeling could be a mechanism linking the use of insulin and being homebound. However, whether such a feeling is specific to the Japanese or not remains to be determined. In this regards, further evaluation is required in the future.

Next, we discuss the association between social isolation, being homebound and a decline in higher level functional capacity. In previous community studies on the older living in a community, decline in physical function and higher level functional capacity was associated with social isolation and being homebound.[3 14] Our study identified a decline in higher level functional capacity as a common factor associated with both social isolation and being homebound, which is consistent with the previous studies. However, the TMIG-IC score was lower than that reported in previous studies[3 14] (10.5 vs 11.7), indicating that it is important to pay attention to a deterioration of higher level functional capacity, social isolation, and being homebound in older patients with diabetes.

In previous community studies among older, male sex,[3 15] living alone[25] and depression[11] were factors associated with social isolation and being homebound. However, these factors were not found to be significant in our study. Social isolation occurred more frequently in men (34.4%) than in women (15.6%).[14] The frequency of social isolation in our study was 34% among men and 27% among women, not as significant as in prior studies. In our study, there was a higher prevalence of cardiovascular disease and diabetic complications. Furthermore, a significantly greater decline in higher level functional

capacity may have resulted to a high frequency of social isolation. One study reported that living alone is a factor associated with social isolation.[25] However, another study showed no association between these two factors.[35] In our study, the low frequency of living alone and the small sample size may have contributed to an insignificant association between living alone and social isolation/being homebound compared with the previous community studies. A previous study demonstrated a greater prevalence of depression among patients with diabetes than in patients with non-diabetes.[36] The prevalence was also high in our study, but the impact of depression on social isolation and being homebound was probably not significant. We recommend further studies regarding sex differences and the presence or absence of an association between living alone and depression for social isolation and being homebound among older patients with diabetes. Although univariate analysis in this study showed a significant association between social isolation and being homebound, multivariate analysis did not demonstrate these associations. Some studies[8 14] reported that social isolation and being homebound are associated with mortality and decreased ADL. These findings are presumed to suggest that these factors should be considered as important outcomes.

Thus, we recommend that clinicians should pay attention to an increase in glycaemic fluctuation and the use of insulin in the early detection of social isolation and being homebound, respectively. Reducing glycaemic fluctuations and insulin usage in older diabetes patients is important for good prognosis and QOL as well as their influence on important social aspects of life (such as social isolation and being homebound). Glycaemic fluctuation and the selection of drugs other than insulin are possible in some patients. Hence, it is important to determine whether modifying these parameters is a countermeasure for social isolation and being homebound.

Our study has several limitations. First, the subjects were outpatients at a clinic specialised in diabetes, and many of these cases were quite severe. Therefore, the results of this study may not be applicable to patients with mild or stable diabetes. Second, this study did not include a measure of health, education history or income that could affect the results.[10 14] Third, data regarding the use of insulin and other drugs for diabetes treatment (the dosing frequency, the type of drug used and the timing of administration) were not collected in this study. Further investigation of the associations between the methods of diabetes drug use, social isolation and being homebound are warranted in the future. Finally, as a cross-sectional study, it is difficult to make statements regarding causality. As mentioned above, we strongly recommend longitudinal interventional studies on glycaemic fluctuation and social isolation as well as the use of insulin and being homebound.

Despite the limitations noted above, this exploratory study examined factors associated with social isolation and being homebound in older patients with diabetes. We identified glycaemic fluctuation and the use of insulin as factors associated with social isolation and being homebound, respectively. In addition, a decline in higher level functional capacity was identified as a common factor associated with both social isolation and being homebound. Thus, in older patients with diabetes, it is important to be aware of the possibility of social isolation in those with large glycaemic fluctuations and to being homebound in those who use insulin, in addition to a decline in higher level functional capacity.

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REFERENCES

1 World Health Organization. World Health Statistics, 2011. Available: http://www.who.int/whosis/whostat/ EN_WHS2011_Full.pdf[Accessed 1 Jan 2020].
2 Statistics Bureau. Portal site of official statistics of Japan, 2010. Available: http://www.e-stat.go.jp/SG1/estat/ListE.do?lid=000001063433 [Accessed 1 Jan 2020].
3 Saito M, Fujiwara Y, Kobayashi E, *et al*. [Prevalence and characteristics of social isolation in the elderly in a dormitory suburb according to household composition]. *Nihon Koshu Eisei Zasshi* 2010;57:785–95.
4 Ganguli M, Fox A, Gilby J, *et al*. Characteristics of rural homebound older adults: a community-based study. *J Am Geriatr Soc* 1996;44:363–70.
5 Cabinet Office Council. *The survey on health consciousness of senior citizens (2002*. Tokyo: The Government of Japan, 2003.
6 Kuiper JS, Zuidersma M, Oude Voshaar RC, *et al*. Social relationships and risk of dementia: a systematic review and meta-analysis of longitudinal cohort studies. *Ageing Res Rev* 2015;22:39–57.
7 Hawton A, Green C, Dickens AP, *et al*. The impact of social isolation on the health status and health-related quality of life of older people. *Qual Life Res* 2011;20:57–67.
8 Sakurai R, Yasunaga M, Nishi M, *et al*. Co-Existence of social isolation and homebound status increase the risk of all-cause mortality. *Int Psychogeriatr* 2019;31:703–11.

9 Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: a meta-analytic review. *PLoS Med* 2010;7:e1000316.
10 Fujita K, Fujiwara Y, Chaves PHM, *et al*. Frequency of going outdoors as a good predictors for incident disability of physical function as well as disability recovery in community-dwelling older adults in rural Japan. *J Epidemiol* 2006;16:261–70.
11 Fujita K, Fujiwara Y, Kumagai S, *et al*. [The frequency of going outdoors, and physical, psychological and social functioning among community-dwelling older adults]. *Nihon Koshu Eisei Zasshi* 2004;51:168–80.
12 Kono A, Kai I, Sakato C, *et al*. Frequency of going outdoors: a predictor of functional and psychosocial change among ambulatory frail elders living at home. *J Gerontol A Biol Sci Med Sci* 2004;59:M275–80.
13 Herr M, Latouche A, Ankri J. Homebound status increases death risk within two years in the elderly: results from a national longitudinal survey. *Arch Gerontol Geriatr* 2013;56:258–64.
14 Fujiwara Y, Nishi M, Fukaya T, *et al*. Synergistic or independent impacts of low frequency of going outside the home and social isolation on functional decline: a 4-year prospective study of urban Japanese older adults. *Geriatr Gerontol Int* 2017;17:500–8.
15 Takahashi T, Nonaka K, Matsunaga H, *et al*. Factors relating to social isolation in urban Japanese older people: a 2-year prospective cohort study. *Arch Gerontol Geriatr* 2020;86:103936.
16 Cho JH-J, Olmstead R, Choi H, *et al*. Associations of objective versus subjective social isolation with sleep disturbance, depression, and fatigue in community-dwelling older adults. *Aging Ment Health* 2019;23:1130–8.
17 Xiang X, Chen J, Kim M. Trajectories of homebound status in Medicare beneficiaries aged 65 and older. *Gerontologist* 2020;60:101–11.
18 Shibui Y, Murayama H, Kawashima T, *et al*. [Classification of Japanese elderly in an urban area at risk of becoming homebound: knowledge for improving prevention strategies]. *Nihon Koshu Eisei Zasshi* 2011;58:935–47.
19 Uchigata Y. The still persistent stigma around diabetes: is there something we can do to make it disappear? *Diabetol Int* 2018;9:209–11.
20 Kato A, Fujimaki Y, Fujimori S, *et al*. Psychological and behavioural patterns of stigma among patients with type 2 diabetes: a cross-sectional study. *BMJ Open* 2017;7:e013425.
21 Seino Y, Nanjo K, Tajima N, *et al*. Report of the Committee on classification and diagnostic criteria of diabetes mellitus. *J Diabetes Investig* 2010;25:859–66.
22 Yoshiuchi K, Matsuhisa M, Katakami N, *et al*. Glycated albumin is a better indicator for glucose excursion than glycated hemoglobin in type 1 and type 2 diabetes. *Endocr J* 2008;55:503–7.
23 Selvin E, Francis LMA, Ballantyne CM, *et al*. Nontraditional markers of glycemia: associations with microvascular conditions. *Diabetes Care* 2011;34:960–7.
24 Kinoshita T, Shimoda M, Sanada J, *et al*. Association of GA/HbA1c ratio and cognitive impairment in subjects with type 2 diabetes mellitus. *J Diabetes Complications* 2016;30:1452–5.
25 Kharicha K, Iliffe S, Harari D, *et al*. Health risk appraisal in older people 1: are older people living alone an "at-risk" group? *Br J Gen Pract* 2007;57:271–6.
26 Koyano W, Shibata H, Nakazato K, *et al*. Measurement of competence: reliability and validity of the TMIG index of competence. *Arch Gerontol Geriatr* 1991;13:103–16.
27 Hanyu H, Maezono M, Sakurai H, *et al*. Japanese version of the test your memory as a screening test in a Japanese memory clinic. *Psychiatry Res* 2011;190:145–8.
28 Muramatsu K, Miyaoka H, Kamijima K, *et al*. The patient health questionnaire, Japanese version: validity according to the mini-international neuropsychiatric interview-plus. *Psychol Rep* 2007;101:952–60.
29 Doi Y, Minowa M, Uchiyama M, *et al*. Psychometric assessment of subjective sleep quality using the Japanese version of the Pittsburgh sleep quality index (PSQI-J) in psychiatric disordered and control subjects. *Psychiatry Res* 2000;97:165–72.
30 Mukai N, Ohara T, Hata J, *et al*. Alternative measures of hyperglycemia and risk of Alzheimer's disease in the community: the Hisayama study. *J Clin Endocrinol Metab* 2017;102:3002–10.
31 Penckofer S, Quinn L, Byrn M, *et al*. Does glycemic variability impact mood and quality of life? *Diabetes Technol Ther* 2012;14:303–10.
32 Martyn-Nemeth P, Quinn L, Penckofer S, *et al*. Fear of hypoglycemia: influence on glycemic variability and self-management behavior in young adults with type 1 diabetes. *J Diabetes Complications* 2017;31:735–41.
33 Heald AH, Anderson SG, Cortes GJ, *et al*. Hypoglycaemia in the over 75s: understanding the predisposing factors in type 2 diabetes (T2DM). *Prim Care Diabetes* 2018;12:133–8.
34 Wang J-S, Chen H, Tang F, *et al*. Associations of fear of hypoglycemia with second-line use of insulin secretagogues or insulin and subsequent glycemic control in patients with type 2 diabetes: an analysis using data from the discover study. *Int J Clin Pract* 2020;74:e13485.
35 Sato T, Kishi R, Suzukawa A, *et al*. Effects of social relationships on mortality of the elderly: how do the influences change with the passage of time? *Arch Gerontol Geriatr* 2008;47:327–39.
36 Chireh B, Li M, D'Arcy C. Diabetes increases the risk of depression: a systematic review, meta-analysis and estimates of population attributable fractions based on prospective studies. *Prev Med Rep* 2019;14:e100822.