Original Article

Comorbid Diabetes and Depression among Older Adults – Prevalence, Correlates, Disability and Healthcare Utilisation

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Abstract

Introduction: The objectives of this current study were to: 1) examine the prevalence and correlates of diabetes mellitus (DM) among older adults (aged 60 years and above) in a multi-ethnic population; 2) examine the prevalence and correlates of comorbid DM and depression among them; and 3) assess the effect of comorbid depression on disability, cognition and healthcare utilisation. Materials and Methods: Data for the current study came from the Well-being of the Singapore Elderly (WiSE) study; a single phase, cross-sectional survey conducted among Singapore residents aged 60 years and above. A total of 2565 respondents completed the survey; depression was assessed using the Automated Geriatric Examination for Computer Assisted Taxonomy (AGECAT) while a diagnosis of DM was considered if respondents stated that a doctor had diagnosed them with DM. Results: DM was reported by 25.5% of the population. The prevalence of depression was significantly higher in those diagnosed with DM than those without DM (6% vs 3%). After adjusting for sociodemographic correlates, smoking and other chronic conditions, DM remained significantly associated with depression and subsyndromal depression. However, after including measures of functioning and cognitive impairment as covariates, DM was not significantly related to depression and subsyndromal depression. Those with comorbid DM and depression were more likely to be of Indian and Malay ethnicity, aged 75 to 84 years (versus 60 to 74 years) and widowed. Conclusion: Given the significant association of certain sociodemographic groups with comorbid depression among those with DM, targeted interventions for prevention and early diagnosis in these groups should be considered.

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Key words: Direct medical care costs, Singapore, Well-being of the Singapore elderly

Introduction

Data from studies across the world suggest that diabetes mellitus (DM) is common among those belonging to the older age group. According to a recent consensus report, the prevalence of DM among those aged ≥65 years varies from 22% to 33% in the United States (US), depending on the diagnostic criteria used.[1] Studies also suggest that depression and DM co-occur frequently.[2] A meta-analysis by Ali et al[3] found the prevalence of depression to be significantly higher in patients with type 2 DM compared with those without (17.6% vs 9.8%). Shared aetiology involving inflammatory response and dysregulation of the hypothalamic-pituitary-adrenal axis have been suggested as possible factors for this comorbidity.[4] This comorbidity leads to poorer health outcomes and increased morbidity.[5] Younger age, lower education, smoking and obesity have been associated with a higher likelihood of meeting criteria for major and minor depression among those with DM.[6]

Few studies have examined the prevalence of comorbid depression and DM among older adults in representative population samples. A study from Hong Kong based on data collected from 1998 to 2001 from elderly health centres reported that after controlling for age, sex and education level, those having regular treatment for DM were 1.3

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times more likely to have depression than older people without DM,[7] while another population-based study from Hong Kong reported that 26% of older adults with DM had elevated depressive symptoms.[8] While adjusting for self-reported disability did not attenuate this association, the association disappeared after adjusting for diabetes-related complications including heart disease, high blood pressure, stroke, and vision problems.[8] A more recent study from Brazil[9] found that 3.6% of the population aged 60 years and above had comorbid depression and DM.

Singapore is a city-state country in Southeast Asia with a population of approximately 5.5 million of which the resident population (Singapore citizens and permanent residents) totalled 3.9 million in 2015.[10] It has a multiethnic urban population comprising mainly of Chinese, Malays and Indians, each a major ethnic group in Asia. The population of older adults (defined as persons aged 65 years and older) in Singapore has grown dramatically; while in 1990 they comprised 6% of the population, this proportion has since increased to 11.8% in 2015.[11] The prevalence of type 2 DM increased from 5% in the 1980s[12] to 11% in 2010.[13] Lifetime and 12-month prevalence of major depressive disorder (MDD) in Singapore were estimated to be 5.8% and 2.2%, respectively.[14] Ethnic differences have been identified in the prevalence of both depression and DM in Singapore with Indians having the highest prevalence of DM (17.2%), followed by Malays (16.6%) and Chinese (9.7%).[13] Lifetime prevalence of MDD was also significantly higher among the Indians (8.1%) than among the Chinese (5.5%) and Malays (4.5%) in Singapore.[14] While prevalence of DM increased with age—from 1% in young adults aged 18 to 29 years to 4.3% among those aged 30 to 39 years and peaked at 29.1% among those aged 60 to 69 years[13]—the prevalence of lifetime MDD was highest in those between 18 and 34 years and lowest among those aged 65 and above.[14] However, few studies have examined comorbid depression and DM in population studies and little is known of the risk factors and consequences.

Using data from a nationwide epidemiological study among older adults in Singapore, the objectives of this current study were to: 1) examine the prevalence and correlates of DM among older adults (aged 60 years and above); 2) examine the prevalence and correlates of comorbid DM and depression in the same population; and 3) assess the effect of comorbid depression on disability, cognition and healthcare utilisation in terms of direct medical care costs.

Materials and Methods

The Well-being of the Singapore Elderly (WiSE) study was a single phase, cross-sectional survey conducted among Singapore residents (including Singapore citizens and permanent residents) aged 60 years and above. A probability sample was randomly selected from a national registry that maintains the names and sociodemographic details such as the age, gender, ethnicity and addresses of all residents in Singapore using a disproportionate stratified sampling design to obtain equivalent proportions of the 3 main ethnic groups in Singapore. In order to make inferences of prevalence rates of mental disorders to the entire Singapore resident population, the survey data were weighted to the 2011 resident population. All respondents were approached at the household; respondents who were in day care centres, nursing homes, and institutions were also included. However, those who were living outside the country and not contactable due to incomplete or incorrect addresses were excluded from the study.

The 10/66 protocol[15] was adopted for this study. The study was approved by the institutional ethics review boards of participating institutions (National Healthcare Group Domain Specific Review Board [DSRB] and the SingHealth Centralised Institutional Review Board [CIRB]). All respondents provided written informed consent and for respondents who were unable to provide informed consent, written informed consent was taken from their legally acceptable representative/next-of-kin. An "informant" was also included in the study (defined as the person who knew the respondent best). Informed consent was also obtained from all informants. The study has been described in greater detail in an earlier article.[16]

Assessment of Depression

The Geriatric Mental State (GMS) examination comprising a semi-structured interview and a rating section covering psychopathology, sensory functions and frailty was used. Diagnoses were obtained using the Automated Geriatric Examination for Computer Assisted Taxonomy (AGECAT).[17] The B3 version of the GMS generates 4 diagnostic clusters: organicity (dementia); schizophrenia and related paranoia; depression; and anxiety neurosis. A diagnostic confidence level is provided for each syndrome, ranging from 0 (no symptoms) to 5 (very severely affected). Level 3 and greater represent a degree of severity warranting professional intervention and levels 1 and 2 are classified as subcases. The validity of AGECAT has been established by Kua[18] in Singapore who reported a concordance of 0.88 (kappa) between AGECAT and the psychiatrist's diagnoses for depression. Similar to the earlier study by Guerra et al,[19] we used the stage 1 GMS-AGECAT depression syndrome for this analysis—this is subsequently referred to as "depression". Those meeting a diagnostic confidence level of 1 or 2 (subcases) were classified as "subsyndromal depression". The decision to use stage 1 diagnosis was based

on the finding that the sensitivity was consistently higher for the stage 1 than for the stage 2 depression diagnosis, against the Montgomery-Åsberg Depression Scale rating in the pilot studies.[20]

Other Assessments

Cognitive Assessment

A cognitive test battery comprising the Community Screening Interview for Dementia (CSI-D)[21] which incorporated the Consortium to Establish a Registry for Alzheimer's Dementia (CERAD) animal naming verbal fluency task, and the modified CERAD 10-word list learning task with delayed recall[22] was administered. This generated the Global Cognitive Score (COGSCORE), an item-weighted total score for cognition.

Diagnosis and Treatment of DM

Respondents were asked if a doctor had ever diagnosed them with DM. Those who reported that they had been diagnosed by a doctor as having DM were then asked if they were managed using diet alone, oral hypoglycaemics or insulin. In cases where respondents were unable to answer the query or were not sure of their answers, the "informant" was used as a proxy to collect the information.

Other Health Conditions

The presence or absence of health conditions was determined by asking respondents whether a doctor had ever told them that they had any of the following: hypertension, heart trouble (myocardial infarction, cardiac failure and valvular heart disease), stroke and transient ischaemic attacks (TIAs).

Disability

The World Health Organization Disability Assessment Schedule II (WHODAS II)[23] was used to measure limitation and participation restriction. The WHODAS II measures functioning across 6 domains – cognition, mobility, self-care, getting along, life activities and participation in community activities over the past 30 days. It uses a 5-point scale that ranges from none (0 – no difficulty) to extreme or cannot do (4 – extreme difficulty).

Resource Utilisation

Data was obtained from respondents and their informants using an adapted version of the Client Service Receipt Inventory (CSRI).[24] The instrument asks whether respondents had used specific services during the 3-month period prior to the interview. Those who endorsed receiving services were then asked in detail about the number of visits, average time spent on visits and out-of-pocket costs. Only direct medical costs were assessed for this study which included care provided by private or public setting in outpatient or inpatient setting, accident and emergency (A&E) care, as well as visits to dentists and traditional healers.

Cost of Medical Care Utilisation

Specific healthcare costs were estimated by multiplying each service unit (i.e. consultations per minute, visits per day) by their own unit cost price. For the estimation of annual costs, the 3-month values were multiplied by 4. Due to variations and paucity of data relating to unit cost from local sources, an alternative approach was used, i.e. extrapolation through application of United Kingdom (UK) unit costs was employed,[25,26] to estimate the unit cost for selected direct medical care (consultations with the primary care doctor, restructured hospital doctor, and other restructured hospital health workers). The relationship between UK and Singapore unit costs for these services were assumed to be fixed and the ratio of costs between the 2 countries to have remained unchanged over the years.[25,26] This approach consisted of the following steps: 1) determination of the reference unit costs (UK) for each specific service, 2) generation of ratios for inpatient and outpatient settings between the reference country (UK) and Singapore using data from the World Health Organisation Choosing Interventions that are Cost-Effective (WHO-CHOICE) database[27] and, 3) application of these ratios to the unit cost of each selected services in the reference country in order to generate country-specific unit costs for Singapore. The Unit Cost of Health and Social Care 2013[28] which is considered a reliable source of UK unit costs was used to identify and match the appropriate unit costs to the reported services.

This approach has been used previously in other population-based cost evaluation studies.[25,26,29,30] For other direct medical care including private healthcare doctors, other private healthcare workers, dentists, traditional healers, A&E and medication, the average out-of-pocket reported expenses amount was used instead of applying the ratios to the UK unit cost as they were deemed more representative of the Singapore population (Table 1).[26]

Body Mass Index

The weight of the respondents was measured using weighing scales after ensuring that the respondent was wearing light clothing. Height was measured by asking the respondent to stand against a wall, marking the height which was then measured using a standard tape measure.

Table 1. Unit Costs for Health and Social Services from the Societal Perspective After Conversion to Singapore Dollars

Healthcare Providers	Unit Cost (S$)	Unit of Activity	Source
Government			
Primary care (polyclinic doctor)	8.39	Minute	PSSRU 2013
Public hospital doctor	17.50	Minute	PSSRU 2013
Other public hospital healthcare worker (e.g. physiotherapist, nurse, MSWs)	1.73	Minute	PSSRU 2013
Private			
Private doctors	99.77	Visit	Out-of-pocket reported expenses (average)
Other private health workers	201.01	Visit	Out-of-pocket reported expenses (average)
Hospital admission	1069.15	Bed day	WHO-CHOICE database

MSWs: Medical social workers; PSSRU: Personal & Social Services Research Unit; WHO-CHOICE (CHOosing Interventions that are Cost-Effective)

Body mass index (BMI) was defined as the weight in kilogrammes divided by the square of the height in metres (kg/m²). WHO cutoff standards were used.[31]

Sociodemographic Information

Participants' age was established from participant report and official identification document. Information was also collected on gender, ethnicity, marital status, education, employment status, income and smoking.

Statistical Analysis

All data analyses were performed using weighted data. To ensure that the survey findings were representative of the Singapore resident elderly population, the data were weighted and analysed using survey data analysis procedures implemented in SAS version 9.2. Multiple logistic regression analyses were used to examine sociodemographic correlates of DM and comorbid DM and depression. Associations between DM and depression, comorbid DM and depression with cognition, functioning and healthcare utilisation were also examined using generalised linear models with adjustment for covariates. To account for the effects of complex sample design due to stratification and weighting,

Table 2. Descriptive Statistics of the Sample (n = 2556)

	Unweighted n	Unweighted %	Weighted %
Age group	-	-	-
60 – 74	1489	58.3	75.1
75 – 84	665	26.0	19.4
85+	402	15.7	5.6
Gender	-	-	-
Men	1111	43.5	44.0
Women	1445	56.5	56.0
Ethnicity	-	-	-
Chinese	1005	39.3	83.2
Malay	745	29.1	9.3
Indian	770	30.1	6.0
Others	36	1.4	1.5
Marital status	-	-	-
Never married	135	5.3	7.9
Married/cohabiting	1480	57.9	64.1
Widowed	832	32.6	22.4
Divorced/separated	107	4.2	5.6
Education	-	-	-
None	510	20.1	16.5
Some, but did not complete primary	618	24.3	23.9
Completed primary	638	25.1	24.8
Completed secondary	515	20.3	22.4
Completed tertiary	261	10.3	12.4
Employment status	-	-	-
Paid work (part-time and full-time)	686	27.2	34.0
Unemployed	32	1.3	1.5
Homemaker	808	32.0	26.4
Retired	1000	39.6	38.1
Received any income, benefits, pensions or allowances	-	-	-
No	371	14.5	10.7
Yes	2181	85.5	89.3
If yes, mean total monthly income (in SGD)	1998	1453.8	1631.7
Smoking	-	-	-
No	1877	73.5	74.5
Yes	676	26.5	25.5
Obesity/overweight	-	-	-
No	1203	52.8	58.0
Yes	1077	47.2	42.0
Diabetes mellitus			
No	1758	68.8	74.5
Yes	798	31.2	25.5

Table 2. Descriptive Statistics of the Sample (n = 2556) (Cont'd)

	Unweighted n	Unweighted %	Weighted %
Depression			
Depression	176	6.9	3.8
Sub-syndromal depression	422	16.5	13.3
No depression	1958	76.6	82.9
Diabetes mellitus and depression			
Comorbid diabetes mellitus and depression	72	2.8	1.5
Diabetes only	726	28.4	24.0
Depression only	104	4.1	2.2
No diabetes or depression	1654	64.7	72.3

standard errors and significance tests were estimated using the Taylor series linearisation method. Multivariate significance was evaluated using the Wald test based on design-corrected coefficient variance-covariance matrices. Statistical significance was set at the conventional level of $P < 0.05$, using two-sided tests.

Results

Prevalence, Treatment and Correlates of DM

A total of 2565 respondents completed the survey giving a response rate of 65.6%. Of these, 2556 individuals responded to the diabetes-related questions and were included in this study. Table 2 shows the descriptive statistics of the sample. The weighted percentage of those who were diagnosed by the doctor as having DM at the point of the survey was 25.5% (n = 798), of whom 79.2% (n = 623) were on oral hypoglycaemics, 12% (n = 100) were on insulin, 3% (n = 30) were managed on special diet alone, 5.1% (n = 40) were not undergoing any treatment and 0.7% (n = 5) were not sure about their treatment.

Relationship between DM and Depression

The prevalence of depression was significantly higher in those diagnosed with DM than those without DM (6% vs 3%; $P = 0.003$). After adjusting for all sociodemographic correlates, smoking and other chronic conditions, individuals with DM were more likely to be of Indian ethnicity, retired and with comorbid conditions. Additionally DM was significantly associated with depression and subsyndromal depression (Model 1, Table 3). However, after including WHODAS II and COGSCORE as a measure of disability and cognitive impairment in the covariates, DM was not significantly related to depression and subsyndromal depression (Model 2, Table 3).

Prevalence and Correlates of Comorbid DM and Depression

The prevalence of comorbid DM and depression in the overall population was 1.5% while among those with DM it was 6% (n = 72). Individuals with comorbid DM and depression as compared to those with DM alone (those with DM and comorbid subsyndromal depression were excluded from this analysis [n=155]) were more likely to be of Indian and Malay ethnicity versus Chinese ethnicity, aged 75 to 84 years (versus the younger age group) and widowed (Model 1, Table 4). After adding WHODAS II and COGSCORE in the subsequent model (Model 2, Table 4), Indian, Malay and Others ethnicity, widowed, homemakers and WHODAS scores remained significantly related to comorbid depression and DM.

Relationship between Comorbid DM and Depression with Disability, Cognition and Resource Utilisation

The mean WHODAS II score was significantly higher among those with comorbid DM and depression than those without this condition. After adjusting for all covariates, comorbid DM and depression was significantly related to WHODAS II score and total direct medical care cost (Table 5). The total annual cost of direct medical care (adjusted mean = S$14,455.64 vs S$10,310.40) including visits to a doctor in a private hospital/clinic (S$1173.86 vs S$720.59) and polyclinic (S$590.06 vs S$370.86) were significantly higher among those with comorbid DM and depression than in those with DM only.

Discussion

DM as diagnosed by a doctor was reported by 25.5% of the population. These values are slightly lower than the prevalence of 29.1% among those aged 60 to 69 years in the National Health Survey conducted in 2010.[13] The national survey included those with previously diagnosed DM as well as those diagnosed by a 2-hour glucose tolerance test which may have accounted for some of the difference. Kirkman et al[1] similarly reported that more than 25% of the US population aged ≥65 years had DM. Ethnic differences in the prevalence of DM identified in the study are similar to previous studies conducted in Singapore. The National Health Survey[13] reported that the prevalence of DM was highest among Indians and lowest among those of Chinese ethnicity. Genetic predisposition and increased insulin resistance have been suggested as putative mechanisms contributing to the increased risk of DM observed among Indians.[32] The association between DM and disability

Table 3. Sociodemographic and Clinical Correlates of Diabetes Mellitus

Demographic Characteristic	Category	Model 1†			Model 2‡		
		OR	95% CI	*P* Value	OR	95% CI	*P* Value
Age group	60 – 74	Ref.			Ref		
	75 – 84	0.9	(0.6, 1.2)	0.449	0.8	(0.6, 1.1)	0.225
	85+	0.6	(0.4, 1)	0.064	0.5	(0.3, 0.9)	0.011
Gender	Men	Ref.			Ref.		
	Women	0.7	(0.5, 1.1)	0.104	0.7	(0.5, 1)	0.083
Ethnicity	Chinese	Ref.			Ref.		
	Indian	2.3	(1.8, 3)	<0.001	2.3	(1.8, 3)	<0.001
	Malay	1.1	(0.9, 1.5)	0.383	1.1	(0.9, 1.5)	0.385
	Others	1.8	(0.9, 3.9)	0.122	1.9	(0.9, 4)	0.113
Marital status	Married	Ref.			Ref.		
	Divorced/ separated	0.9	(0.4, 1.8)	0.783	0.9	(0.4, 1.8)	0.774
	Never married	0.98	(0.5, 1.8)	0.945	0.98	(0.5, 1.8)	0.938
	Widowed	1.1	(0.8, 1.6)	0.678	1.04	(0.7, 1.5)	0.839
Education	Completed tertiary	Ref.			Ref.		
	None	1.3	(0.7, 2.4)	0.345	1.3	(0.7, 2.4)	0.337
	Some, but did not complete primary	1.1	(0.7, 1.9)	0.705	1.1	(0.7, 1.9)	0.660
	Completed primary	0.96	(0.6, 1.6)	0.871	0.98	(0.6, 1.6)	0.931
	Completed secondary	0.9	(0.5, 1.5)	0.596	0.9	(0.5, 1.5)	0.634
Employment	Paid work (part-time and full-time)	Ref.			Ref.		
	Homemaker	1.5	(0.9, 2.5)	0.085	1.5	(0.9, 2.4)	0.119
	Retired	1.7	(1.2, 2.5)	0.005	1.6	(1.1, 2.4)	0.009
	Unemployed	0.5	(0.2, 1.6)	0.248	0.5	(0.1, 1.6)	0.240
Obesity/overweight	No	Ref.			Ref.		
	Yes	1.3	(0.9, 1.7)	0.127	1.3	(0.9, 1.7)	0.128
Smoking	No	Ref.			Ref.		
	Yes	1.1	(0.8, 1.6)	0.658	1.1	(0.7, 1.5)	0.745
Depression	No depression	Ref.			Ref.		
	Cases	2.2	(1.3, 3.9)	0.005	1.7	(1, 3.1)	0.073
	Subcases	1.6	(1, 2.3)	0.028	1.4	(0.9, 2.1)	0.094
Any other chronic condition*	No	Ref.			Ref.		
	Yes	3.2	(2.3, 4.5)	<0.001	3.1	(2.2, 4.4)	<0.001
WHODAS II					1.02	(1.004, 1.03)	0.008
COGSCORE					1.02	(0.97, 1.07)	0.465

CI: Confidence interval; COGSCORE: Global Cognitive Score; OR: Odds ratio; WHODAS: World Health Organization Disability Assessment Schedule

*Includes hypertension, heart problem, heart attack, stroke and transient ischaemic attack.

†Multiple logistic regression adjusting for age, gender, ethnicity, marital status, education, employment status, obesity/overweight, smoking, depression and any other chronic condition.

‡Multiple logistic regression adjusting for age, gender, ethnicity, marital status, education, employment status, obesity/overweight, smoking, depression, any other chronic condition, COGSCORE and WHODAS II.

Table 4. Sociodemographic and Clinical Correlates of Comorbid Diabetes Mellitus and Depression[†]

Demographic Characteristic	Category	Model 1[‡]			Model 2[§]		
		OR	95% CI	*P* Value	OR	95% CI	*P* Value
Age group	60 – 74	Ref.			Ref.		
	75 – 84	2.5	(1, 6.3)	0.047	1.9	(0.6, 5.7)	0.264
	85+	1.5	(0.2, 11.7)	0.719	0.3	(0.01, 8)	0.494
Gender	Men	Ref.					
	Women	4	(0.9, 18.3)	0.078	4.7	(0.8, 27.2)	0.086
Ethnicity	Chinese	Ref.					
	Indian	4.9	(2.1, 11.3)	<0.001	6.6	(2.6, 16.5)	<0.0001
	Malay	4	(1.6, 9.8)	0.003	5.2	(1.9, 14.2)	0.001
	Others	6.6	(1, 45.5)	0.056	16.8	(3, 94.8)	0.001
Marital status	Married	Ref.					
	Divorced/separated	0.1	(0,1)	0.053	0.2	(0, 1.3)	0.096
	Never married	2.8	(0.3, 28.8)	0.396	4	(0.4, 36.5)	0.215
	Widowed	0.2	(0.1, 0.6)	0.004	0.1	(0.01, 0.4)	0.006
Education	Completed tertiary	Ref.			Ref.		
	None	2.9	(0.3, 30.2)	0.379	3.4	(0.6, 18.7)	0.167
	Some, but did not complete primary	0.6	(0.1, 5.4)	0.608	1.1	(0.2, 6.1)	0.871
	Completed primary	0.8	(0.1, 7.2)	0.806	1.3	(0.2, 8.5)	0.795
	Completed secondary	0.7	(0.1, 4.1)	0.708	0.8	(0.2, 3)	0.749
Employment	Paid work (part-time and full-time)	Ref.			Ref.		
	Homemaker	0.5	(0.1, 2.1)	0.324	0.2	(0, 1)	0.044
	Retired	0.8	(0.3, 2.2)	0.730	0.7	(0.3, 2.1)	0.540
	Unemployed	2.1	(0.2, 24.5)	0.547	2.7	(0.2, 44.8)	0.499
Obese/overweight	No	Ref.			Ref.		
	Yes	1.004	(0.4, 2.8)	0.995	1.2	(0.4, 3.4)	0.782
Smoking	No	Ref.			Ref.		
	Yes	1.9	(0.6, 6.2)	0.276	1.5	(0.4, 5.5)	0.513
Diabetes treatment	Oral hypoglycaemics	Ref.			Ref.		
	Diet alone	2.1	(0.5, 8.4)	0.274	0.99	(0.2, 4.9)	0.991
	Insulin	2.2	(0.7, 7.6)	0.192	0.8	(0.2, 3)	0.782
	No treatment	3	(0.7, 12.6)	0.143	3.3	(0.4, 25.5)	0.254
Any other chronic condition[*]	No	Ref.			Ref.		
	Yes	1.4	(0.6, 3.4)	0.448	0.7	(0.2, 2.1)	0.542
COGSCORE					1.1	(0.9, 1.2)	0.349
WHODAS II					1.1	(1.1, 1.2)	<0.0001

COGSCORE: Global Cognitive Score; WHODAS: World Health Organization Disability Assessment Schedule

[*]Any other chronic condition includes hypertension, heart problem, heart attack, stroke and transient ischaemic attack.

[†]The analysis excluded those with subsyndromal depression.

[‡]Multiple logistic regression adjusting for age, gender, ethnicity, marital status, education, employment status, obesity/overweight, smoking, diabetes treatment and any other chronic condition.

[§]Multiple logistic regression adjusting for age, gender, ethnicity, marital status, education, employment status, obesity/overweight, smoking, diabetes treatment, any other chronic condition, COGSCORE and WHODAS II.

Table 5. Relationship between Comorbid Diabetes Mellitus and Depression with Cognition, Disability and Direct Medical Care

	Comorbid Diabetes and Depression					Multivariate Regression Analyses		
	Yes (n = 72)		No (n = 571)					
	Unadjusted Mean	**SE**	**Unadjusted Mean**	**SE**	***P* Value**	**Beta Coefficient‡**	**95% CI**	***P* Value**
COGSCORE	26.98	0.79	27.94	0.27	0.844	-0.002	(-0.041, 0.036)	0.901
WHODAS II	31.64	4.80	11.94	1.07	<0.001	0.809	(0.749, 0.870)	<0.001
Annual Direct Medical Care Contacts and Costs (S$)	**Unadjusted Mean**	**SE**	**Unadjusted Mean**	**SE**	***P* Value**	**Beta Coefficient‡**	**95% CI**	***P* Value**
Primary care (polyclinic doctor)								
Number of visits	5.43	0.53	5.41	0.48	0.979	0.066	(-0.146, 0.278)	0.539
Cost	767.53	175.05	575.32	91.27	0.304	0.481	(0.940, 0.868)	0.015
Public hospital doctor*								
Number of visits	9.87	-	6.48	-	-	-	-	-
Cost	2573.88	-	2021.73	-	-			
Other public hospital health worker*								
Number of visits	5.12	-	10.8	-	-	-	-	-
Cost	120.74	-	903.8	-	-			
Private hospital/clinic doctor								
Number of visits	9.18	1.57	6.83	0.48	0.109	0.089	(-0.133, 0.311)	0.430
Cost	938.19	365.53	530.14	64.25	0.161	0.597	(0.097, 1.10)	0.020
Other private healthcare worker*								
Number of visits	18.01	-	24.41	-	-	-	-	-
Cost	2938.22	-	3348.40					
Dentist*								
Number of visits	4.00	-	7.66	-	-	-	-	-
Cost	600		4339.43					
Traditional healer								
Number of visits	21.32	-	16.69	-	-	-	-	-
Cost	1151.40	-	808.46					
Hospital admissions*								
Number of visits	41.95	-	46.16	-	-	-	-	-
Cost	48,850.26	-	49,354.56					
Emergency department/e-room†								
Cost	6065.88	-	2642.3	-	-	-	-	-
Medication								
Cost	861.33	231.40	862.33	218.92	0.997	0.073	(-0.381, 0.526)	0.754
Total direct medical care								
Cost	11,852.28	3513.16	6525.87	1357.31	0.102	0.809	(0.080, 1.538)	0.030

COGSCORE: Global Cognitive Score; WHODAS: World Health Organization Disability Assessment Schedule

*The standard error of the mean (SE), *P* values and regression coefficient were not estimated by the statistical software due to small sample size.

†The number of visits was not available in the scale.

‡Coefficient was derived using multivariate regression models after adjusting for sociodemographic factors, obesity, smoking, diabetes treatment and any chronic condition.

has been highlighted in a number of studies.[33-35] Various mechanisms including limitation in physical activity,[36,37] association with cardiovascular complications,[38] and hypoglycaemia[39] have been suggested to explain this relationship.

The study found a significant comorbidity between DM and depression, about twice what would have been expected by chance alone. These findings are similar to other reported findings in the literature.[40-41] This association was retained even after controlling for age, gender, ethnicity, education and comorbid medical conditions but it disappeared after controlling for WHODAS scores suggesting that this association may be mediated by disability.

The prevalence of comorbid DM and depression in this population and among those with DM was 1.5% and 6%, respectively. A recent systematic review[42] estimated higher prevalence rate of depression in people with type 1 (12% vs 3.2%) and type 2 DM (19.1% vs 10.7%) compared to those without. The prevalence of comorbidity is lower in our study which may be due to either methodological differences such as the use of population-based Asian sample, the inclusion of only older adults in the current study or the low prevalence of depression in this population.[43]

Other studies have identified ethnic differences in the association of depressive symptoms with DM.[44,45] Our findings of a significant association of depressive symptoms among patients with DM of Indian, Malay and Other ethnicities suggests some underlying mediating factors which may be biological, e.g. genetic,[46] psychosocial or dietary in nature. While the current study identified an association between widowhood and comorbidity, the evidence relating widowhood to poor health status and negative health behaviours is inconsistent. However, some studies have identified an association between widowhood and impairment in social functioning, depressed mood and poor physical health.[47,48]

Disability, as measured by WHODAS score, was found to be significantly associated with comorbid DM and depression. Other studies have found that the risk of diabetic complications is higher among those with DM and comorbid depression than in those with DM alone.[49] Blay et al[9] found that older adults with comorbid depression and DM were significantly more likely to have problems in their activities of daily living, and were more likely to have comorbid vascular, respiratory, urinary, and musculoskeletal disorders. Thus, comorbidity or diabetic complications may result in increased disability in the comorbid group.

Contrary to a number of other studies, we did not find an association with BMI, smoking, and education with comorbid depression and DM in the adjusted models. The study also did not find a clear pattern of higher resource utilisation among those with comorbid DM and depression. Those with comorbid depression and DM had a higher mean number of visits to doctors both in the public and private setting. They also reported more visits to traditional healers. The cost of visits to both polyclinic doctors and doctors in private setting was higher among those with comorbid DM and depression. Due to the rather small sample size of those with comorbidity, our analysis is limited. A systematic review by Hutter et al[50] similarly concluded that the number and costs of outpatient visits and total healthcare costs were increased in patients with DM and comorbid mental disorders compared with diabetic patients without such disorders. The authors further cautioned that while the increase in healthcare cost due to depression amongst those with DM may not be substantial, patients with DM already use healthcare services to a notable degree. Given this, even small to moderate increases of utilisation and cost in this group would translate into significantly increased consumption of services for healthcare providers and an increased cost burden from a policy perspective.[50]

The limitations of the study include its cross-sectional design which did not enable us to establish the temporal relation of depression and DM. There is also a possibility of under-reporting of DM and depressive symptoms among older adults which may have contributed to some of the findings. Since diagnosis of diabetes was established on the basis of self-report, we were unable to classify the type of diabetes (although we expect that the vast majority had type 2 diabetes), duration of illness or severity. Recall bias may have affected both the number of visits reported and the amount spent per visit, as the study procedures did not include checking of appointment cards or actual receipts of amount spent. The response rate of the study was about 66% and little medical data was available on those who refused to participate in the study, thus limiting the generalisability of our results to that population. Lastly, we were unable to estimate the standard error of the mean, and regression coefficient for the costs related to some of the services included in direct medical care due to the small sample size. However, the strengths include the overall large sample size, the multi-ethnic nature of the population and use of validated and structured instruments. For most of the older adults, corroborative data was also collected from an informant which reduced the probability of under-reporting by the older respondent.

Conclusion

Studies suggest that the course of DM is worsened by comorbid depression. Depression in DM has been associated with lack of self-care including failure to follow dietary restrictions and reduced physical activity,[51,52] reduced quality of life[53] and increased healthcare utilisation.[54] Thus, early

diagnosis and management of depression in patients with diabetes is essential for ensuring good outcomes. Given the significant associations of certain sociodemographic groups with comorbid depression among those with diabetes, targeted interventions for prevention and early diagnosis in these groups should be considered. For patients with comorbid depression and DM, nurse-led shared care programmes that are patient-centred and use guideline-based management of both depression and chronic disease have been shown to achieve good outcomes.[2,55]

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REFERENCES

1. Kirkman MS, Briscoe VJ, Clark N, Florez H, Haas LB, Halter JB, et al. Diabetes in older adults: a consensus report. J Am Geriatr Soc 2012;60:342-56.
2. Katon WJ, Lin EH, Von Korff M, Ciechanowski P, Ludman EJ, Young B, et al. Collaborative care for patients with depression and chronic illnesses. N Engl J Med 2010;363:2611-20.
3. Ali S, Stone M, Peters J, Davies M, Khunti K. The prevalence of co-morbid depression in adults with type 2 diabetes: a systematic review and meta-analysis. Diabet Med 2006;23:1165-73.
4. Moulton CD, Pickup JC, Ismail K. The link between depression and diabetes: the search for shared mechanisms. Lancet Diabetes Endocrinol 2015;3:461-71.
5. Egede LE. Effect of depression on self-management behaviors and health outcomes in adults with type 2 diabetes. Curr Diabetes Rev 2005;1:235-43.
6. Katon W, von Korff M, Ciechanowski P, Russo J, Lin E, Simon G, et al. Behavioral and clinical factors associated with depression among individuals with diabetes. Diabetes Care 2004;27:914-20.
7. Chau PH, Woo J, Lee CH, Cheung WL, Chen J, Chan WM, et al. Older people with diabetes have higher risk of depression, cognitive and functional impairments: implications for diabetes services. J Nutr Health Aging 2011;15:751-5.
8. Chou KL, Chi I. Prevalence of depression among elderly Chinese with diabetes. Int J Geriatr Psychiatry 2005;20:570-5.
9. Blay SL, Fillenbaum GG, Marinho V, Andreoli SB, Gastal FL. Increased health burden associated with comorbid depression in older Brazilians with diabetes. J Affect Disord 2011;134:77-84.
10. Statistics Singapore. Latest Data on resident population profile. 2015. Available at: http://www.singstat.gov.sg/statistics/latest-data#15. Accessed on 13 August 2016.
11. Statistics Singapore. Population Trends. 2014. Available at: http://www.singstat.gov.sg/docs/default-source/default-document-library/publications/publications_and_papers/population_and_population_structure/population2015.pdf. Accessed on 13 August 2016.
12. Thai AC, Yeo PP, Lun KC, Hughes K, Ng WY, Lui KF, Cheah JS. Diabetes mellitus and its chronic complications in Singapore: an increasing healthcare problem. Ann Acad Med Singapore 1990;19:517-23.
13. Ministry of Health, Singapore, Epidemiology and Disease Control Division. National Health Survey 2010. Singapore: Government of Singapore, 2011. Available at: https://www.moh.gov.sg/content/dam/moh_web/Publications/Reports/2011/NHS2010%20-%20low%20res.pdf. Accessed on 13 August 2016.
14. Chong SA, Vaingankar J, Abdin E, Subramaniam M. The prevalence and impact of major depressive disorder among Chinese, Malays and Indians in an Asian multi-racial population. J Affect Disord 2012;138:128-36.
15. Prince M, Ferri CP, Acosta D, Albanese E, Arizaga R, Dewey M, et al. The protocols for the 10/66 dementia research group population-based research programme. BMC Public Health 2007;7:165.
16. Subramaniam M, Chong SA, Vaingankar JA, Abdin E, Chua BY, Chua HC, et al. Prevalence of dementia in people aged 60 years and above: results from the WiSE study. J Alzheimers Dis 2015;45:1127-38.
17. Copeland JRM, Kelleher MJ, Kellett JM. A semi-structured clinical interview for the assessment of diagnosis and mental state in the elderly. The Geriatric Mental State schedule. Development and reliability. Psychol Med 1976;6:439-49.
18. Kua EH. A community study of mental disorders in elderly Singaporean Chinese using the GMS-AGECAT package. Aust N Z J Psychiatry 1992;6:502-6.
19. Guerra M, Ferri CP, Sosa AL, Salas A, Gaona C, Gonzales V, et al. Late-life depression in Peru, Mexico and Venezuela: the 10/66 population-based study. Br J Psychiatry 2009;195:510-15.
20. Prince M, Acosta D, Chiu H, Copeland J, Dewey M, Scazufca M, et al. Effects of education and culture on the validity of the Geriatric Mental State and its AGECAT algorithm. Br J Psychiatry 2004;185:429-36.
21. Hall KS, Hendrie HH, Brittain HM, Norton JA, Rodgers DD, Prince CS, et al. The development of a dementia screening interview in two distinct languages. Int J Methods Psychiatric Res 1993;3:1-28.
22. Ganguli M, Chandra V, Gilbey J. Cognitive test performance in a community-based non demented elderly sample in rural India: the Indo-US cross national dementia epidemiology study. Int Psychogeriatr 1996;8:507-24.
23. Rehm J, Ustun TB, Saxena S. On the development and psychometric testing of the WHO screening instrument to assess disablement in the general population. Int J Methods Psychiatric Res 2000;8:10-22.
24. Beecham J, Knapp M. Costing psychiatric interventions. In: Thornicroft G, editor. Measuring mental health needs. London: Gaskell; 2001. p. 200-24.
25. Picco L, Achilla E, Abdin E, Chong SA, Vaingankar JA, McCrone P, et al. Economic burden of multimorbidity among older adults: impact on healthcare and societal costs. BMC Health Serv Res 2016;16:173.
26. Abdin E, Subramaniam M, Achilla E, Chong SA, Vaingankar JA, Picco L, et al. The societal cost of dementia in Singapore: results from the WiSE Study. J Alzheimers Dis 2016;51:439-4.
27. World Health Organization. Cost effectiveness and strategic planning (WHO-CHOICE). Available at: http://www.who.int/choice/en/. Accessed on 13 August 2016.
28. Curtis L. Unit costs of health and social care. Caterbury: Personal Social Services Research Unit, University of Kent; 2013.
29. Rheingans RD, Antil L, Dreibelbis R, Podewils LJ, Bresee JS, Parashar UD. Economic costs of rotavirus gastroenteritis and cost-effectiveness of vaccination in developing countries. J Infect Dis 2009;200:S16-27.
30. Undurraga EA, Betancourt-Cravioto M, Ramos-Castañeda J, Martínez-

Vega R, Méndez-Galván J, Gubler DJ, et al. Economic and disease burden of dengue in Mexico. PLoS Negl Trop Dis 2015;9:e000354.

31. WHO. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. WHO Technical Report Series 854. Geneva: World Health Organization, 1995.
32. Mohan V. Why are Indians more prone to diabetes? J Assoc Physicians India 2004;52:468-74.
33. Gregg EW, Beckles GL, Williamson DF, Leveille SG, Langlois JA, Engelgau MM, et al. Diabetes and physical disability among US adults. Diabetes Care 2000;23:1272-7.
34. Gregg EW, Mangione CM, Cauley JA, Thompson TJ, Schwartz AV, Ensrud KE, et al. Diabetes and incidence of functional disability in older women. Diabetes Care 2002;25:61-7.
35. Maggi S, Noale M, Gallina P, Marzari C, Bianchi D, Limongi F, et al. Physical disability among older Italians with diabetes. The ILSA study. Diabetologia 2004;47:1957-62.
36. Cederlund RI, Thomsen N, Thrainsdottir S, Eriksson KF, Sundkvist G, Dahlin LB. Hand disorders, hand function, and activities of daily living in elderly men with type 2 diabetes. J Diabetes Complications 2009;23:32-9.
37. Assari S, Lankarani RM, Lankarani MM. Cross-country differences in the association between diabetes and disability. J Diabetes Metab Disord 2014;13:3.
38. Kalyani RR, Saudek CD, Brancati FL, Selvin E. Association of diabetes, comorbidities, and A1C with functional disability in older adults: results from the National Health and Nutrition Examination Survey (NHANES), 1999-2006. Diabetes Care 2010;33:1055-60.
39. Abdelhafiz AH, Rodríguez-Mañas L, Morley JE, Sinclair AJ. Hypoglycemia in older people - a less well recognized risk factor for frailty. Aging Dis 2015;6:156-67.
40. Katon W. Depression and diabetes, unhealthy bedfellows. Depress Anxiety 2010;27:323-6.
41. Nouwen A, Winkley K, Twisk J, Lloyd CE, Peyrot M, Ismail K, et al. for the European Depression in Diabetes (EDID Research Consortium). Type 2 diabetes mellitus as a risk factor for the onset of depression, a systematic review and meta-analysis. Diabetologia 2010;53:2480-6.
42. Roy T, Lloyd CE. Epidemiology of depression and diabetes: a systematic review. J Affect Disord 2012;142:S8-21.
43. Subramaniam M, Abdin E, Sambasivam R, Vaingankar JA, Picco L, Pang S, et al. Prevalence of depression among older adults – results from the WiSE Study. Ann Acad Med Singapore 2016;45:123-33.
44. Chong SA, Subramaniam M, Chan YH, Chua HC, Liow PH, Pek E, et al. Depressive symptoms and diabetes mellitus in an Asian multiracial population. Asian J Psychiatr 2009;2:66-70.
45. Blazer DG, Moody-Ayers S, Craft-Morgan J, Burchett B. Depression in diabetes and obesity: racial/ethnic/gender issues in older adults. J Psychosom Res 2002;53:913-6.
46. Chiba M, Suzuki S, Hinokio Y, Hirai M, Satoh Y, Tashiro A, et al. Tyrosine hydroxylase genet microsatellite polymorphism associated with insulin resistance in depressive disorder. Metabolism 2000;49:1145-9.
47. Wilcox S, Evenson KR, Aragaki A, Wassertheil-Smoller S, Mouton CP, Loevinger BL. The effects of widowhood on physical and mental health, health behaviors, and health outcomes: The Women's Health Initiative. Health Psychol 2003;22:513-22.
48. Stroebe M, Schut H, Stroebe W. Health outcomes of bereavement. Lancet 2007;370:1960-73.
49. Dufton JA, Li WW, Koehoorn M. A comparison of diabetic complications and health care utilization in diabetic patients with and without comorbid depression. BCMJ 2007;49:436-40.
50. Hutter N, Schnurr A, Baumeister H. Healthcare costs in patients with diabetes mellitus and comorbid mental disorders – a systematic review. Diabetologia 2010;53:2470-9.
51. Lerman I, Lozano L, Villa AR, Hernández-Jiménez S, Weinger K, Caballero AE, et al. Psychosocial factors associated with poor diabetes self-care management in a specialized center in Mexico City. Biomed Pharmacother 2004;58:566-70.
52. Chiu CJ, Wray LA, Beverly EA, Dominic OG. The role of health behaviors in mediating the relationship between depressive symptoms and glycemic control in type 2 diabetes: a structural equation modeling approach. Soc Psychiatry Psychiatr Epidemiol 2010;45:67-76.
53. Verma SK, Luo N, Subramaniam M, Sum CF, Stahl D, Liow PH, et al. Impact of depression on health related quality of life in patients with diabetes. Ann Acad Med Singapore 2010;39:913-7.
54. Subramaniam M, Sum CF, Pek E, Stahl D, Verma S, Liow PH, et al. Comorbid depression and increased health care utilisation in individuals with diabetes. Gen Hosp Psychiatry 2009;31:220-4.
55. Coventry P, Lovell K, Dickens C, Bower P, Chew-Graham C, McElvenny D, et al. Integrated primary care for patients with mental and physical multimorbidity: cluster randomised controlled trial of collaborative care for patients with depression comorbid with diabetes or cardiovascular disease. BMJ 2015;350:h638.