BMJ Open

Multimorbidity in cardiovascular disease and association with life satisfaction: a Chinese national cross-sectional study

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To cite: Liu G, Xue Y, Liu Y, *et al*. Multimorbidity in cardiovascular disease and association with life satisfaction: a Chinese national cross-sectional study. *BMJ Open* 2020;**10**:e042950. doi:10.1136/bmjopen-2020-042950

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2020-042950).

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Received 20 July 2020
Revised 08 September 2020
Accepted 08 December 2020

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ABSTRACT

Background The coexistence of multiple chronic conditions is very common in cardiovascular disease (CVD). However, the prevalence of CVD multimorbidity in China and its influence on life satisfaction have not been reported. This study aimed to investigate the proportions of 12 chronic comorbid diseases in CVD and the associations of multimorbidity with life satisfaction in patients with CVD.

Methods We conducted a cross-sectional study in a nationally representative sample of 3478 participants with CVD aged 45 years or more who participated in the China Health and Retirement Longitudinal Study 2015. Correlations of multimorbidity with 12 chronic diseases in CVD and life satisfaction were investigated using logistic regression models, after adjusting for 12 covariates.

Results The proportion of multimorbidity among participants with CVD was 93.3% (89.4% for middle-aged adults and 95.4% for older adults; 92.9% for men and 93.5% for women). The proportion of participants with CVD multimorbidity who were dissatisfied with life was 11.2%, significantly higher than those without any chronic diseases (χ^2=5.147, p=0.023). Life satisfaction in patients with CVD decreased with increased number of comorbidities (χ^2=45.735, p<0.001). Kidney disease (OR=1.933, 95% CI: 1.483 to 2.521), memory-related diseases (MRDs) (OR=1.695, 95% CI: 1.149 to 2.501) and dyslipidaemia (OR=1.346, 95% CI: 1.048 to 1.729) were significantly associated with reduced life satisfaction when adjusting for 12 covariates.

Conclusions In this nationally representative cross-sectional study, life satisfaction was reduced by multimorbidity of CVD. Kidney disease had the greatest influence on life satisfaction in patients with CVD, followed by dyslipidaemia and MRDs. Our study emphasises the importance of preventing of chronic diseases in adults with CVD.

Strengths and limitations of this study

- ► Participants recruited in China Health and Retirement Longitudinal Study were nationally representative of Chinese middle-aged and older adults.
- ► To the best of our knowledge, this is the first nationally representative analysis of the association of cardiovascular disease multimorbidity with life satisfaction.
- ► Life satisfaction was investigated using only one question; therefore, certain aspects of life satisfaction could not be measured.
- ► This study only included 12 of the most common chronic diseases.

INTRODUCTION

Cardiovascular disease (CVD) is a major public health problem that has reached epidemic proportions in China and other countries. China now faces enormous pressure because of its ageing population. The ageing of the Chinese population is accelerating; in 2015, 220 million people in China were age ≥60 years old.[1] Age-related changes in cardiovascular structure, physiology and biology increase the susceptibility to CVD.[2] It was reported that more than 70% of adults develop CVD by the age of 70.[3] The WHO estimated that 20 million people died of CVD in 2015.[4] In China, CVD is becoming more prevalent and it was the main cause of death in 2015.[5] With advancing medical technology and population ageing, increasingly more adults with chronic CVD survive to older ages. Multimorbidity, the coexistence of multiple chronic conditions in an individual, is very common in CVD,[6] and it is reported that more than 50% CVD patients have at least one additional disease.[7]

Except for coexisting multiple CVDs, CVD coexisting with non-CVD morbidities can substantially impact the clinical features, diagnosis, management and outcome of most older patients.[8] The WHO has pointed out that approximately 13% of CVD deaths are associated with diabetes,[9] hypertension[10] and dyslipidaemia,[11] which are recognised as the most common occurrences of multimorbidity with CVD.

The presence of multiple chronic conditions greatly increases the complexity of managing patients with CVD and the burden

of the disease.[12] Patients with CVD who have multiple conditions have greater difficulty with activities of daily living and a poor health status.[13] It is reported that the quality of life can significantly be affected by multimorbidity among CAD patients.[14] Life satisfaction is a construct of the subjective well-being related to how people evaluate the quality of their lives,[12 15] and it is increasingly recognised as an important determinant of health.[16] Therefore, an investigation of the life satisfaction in patients with CVD who have multiple chronic diseases is a feasible way of understanding their quality of life and well-being to improve life satisfaction among patients with CVD. Although life satisfaction has been reported to be associated with increasing proportions of multimorbidity accumulation,[17] no studies on the association of life satisfaction and inpatients with CVD who have multiple chronic diseases have been conducted. The aim of the present was to investigate the association of life satisfaction and chronic disease comorbidity with CVD (referred to as CVD multimorbidity) in a representative Chinese national sample.

METHODS

Study sample

The China Health and Retirement Longitudinal Study (CHARLS) is an ongoing health survey of the Chinese population.[18] Conducted by the National School for Development (China Center for Economic Research), it is a large-scale, multistage and nationally representative of the 30 provinces of China. Participants are investigated face to face in their homes using questionnaires via computer-assisted personal interviewing technology. All respondents signed informed consent forms.

We investigated data of 3478 participants with records of CVD, life satisfaction and age in the CHARLS 2015 database.

Life satisfaction

Life satisfaction was self-rated as 'completely satisfied', 'very satisfied', 'somewhat satisfied', 'not very satisfied' or 'not at all satisfied', using the following question: "Please think about your life as a whole. How satisfied are you with your life?". People who responded 'completely satisfied', 'very satisfied' or 'somewhat satisfied' were classified as satisfied; the remainder were classified as unsatisfied. This one-dimensional life satisfaction measurement was based on the general perception of life, rather than with special aspects of life, and is commonly used in large-scale, nationwide surveys in China.[19]

CVD and other chronic diseases

CVD comprises heart disease and stroke, and it was determined if the respondent had it in face-to-face interviews using the following question: "Have you ever been diagnosed with heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems, or stroke by a doctor?". Participants reporting heart disease or stroke were defined as having CVD. Researchers checked medications that these participants were taking or the receipts in their clinical records for those who reported CVD.

Comorbid diseases included hypertension, dyslipidaemia (elevation of triglyceride, total cholesterol, low-density lipoprotein or high-density lipoprotein levels), hyperglycaemia including diabetes, cancer excluding minor skin cancers, lung disease (eg, chronic bronchitis or emphysema) excluding lung tumours or cancer, liver disease excluding fatty liver disease, liver tumours or cancer, kidney disease excluding kidney tumour or cancer, stomach or other digestive tract disease excluding digestive tumour or cancer, emotional, nervous or psychiatric disorder, memory-related diseases (MRDs), arthritis or rheumatism (AR) and asthma. This information was acquired using the same method as for CVD.

Covariate assessment

Based on previous analyses of life satisfaction, we included several relevant covariates in our study: age, sex, marital status, place of residence, smoking, alcohol consumption, social activity, older age insurance, health insurance, sleep duration(hours) and nap duration (minutes). These were all collected using standardised questionnaires during the interviews. Age was classified as middle age (<60 years) and older age (≥60 years). Marital status was categorised as married (married and living as married), divorced or widowed and single (never married and separated). Place of residence was categorised as family housing and other housing (nursing home or hospital). Smoking and alcohol consumption were both categorised as yes (current smoking or alcohol consumption), former (former but not current smoking or alcohol consumption) and no (never smoking or alcohol consumption). For social activity, the inactive group was defined as those with no reported physical activity, interaction with friends such as playing chess or cards, providing help to people they do not live with, engaging in sports, belonging to a community-related organisation, charity work, caring for a sick or disabled adult, attending courses or use of the internet in the previous month. Older age insurance and health insurance were classified as yes and no. Sleep duration and nap duration were average times per day in the past month.

Statistical analyses

Mean (SD) or median (IQR) are used for continuous variables and frequency (percentage) for categorical variables. The χ^2 test was used for comparing categorical variables and the Wilcoxon rank-sum test was used for comparing continuous variables. Association of life satisfaction with the number of comorbid chronic diseases in CVD was analysed via linear-by-linear χ^2 test. Logistic regression was used in the association analysis of sex (or age), number of chronic diseases comorbid with CVD and life satisfaction. Associations of CVD multimorbidity with life satisfaction were analysed via logistic regression

Table 1 Multimorbidity among patients with cardiovascular disease in China grouped by age and sex

Chronic disease	Total	Age				Sex			
		Middle* (n=1251)	Older† (n=2227)	χ^2	P value	Male (n=1449)	Female (n=2029)	χ^2	P value
Hypertension	1951 (56.1)	613 (49)	1338 (60.1)	39.929	<0.001	849 (58.6)	1102 (54.3)	6.286	0.012
Dyslipidaemia	1161 (33.4)	398 (31.8)	763 (34.3)	2.156	0.142	503 (34.7)	658 (32.4)	1.983	0.159
High blood sugar	641 (18.4)	191 (15.3)	450 (20.2)	12.997	<0.001	254 (17.5)	387 (19.1)	1.341	0.247
Cancer	95 (2.7)	29 (2.3)	66 (3)	1.256	0.262	24 (1.7)	71 (3.5)	10.806	0.001
Lung disease	861 (24.8)	236 (18.9)	625 (28.1)	36.396	<0.001	388 (26.8)	473 (23.3)	5.449	0.020
Liver disease	402 (11.6)	158 (12.6)	244 (11)	2.194	0.139	174 (12)	228 (11.2)	0.492	0.483
Kidney disease	611 (17.6)	212 (16.9)	399 (17.9)	0.520	0.471	287 (19.8)	324 (16)	8.600	0.003
Digestive disease	1445 (41.5)	530 (42.4)	915 (41.1)	0.540	0.462	506 (34.9)	939 (46.3)	44.906	<0.001
ENP disorder	175 (5)	52 (4.2)	123 (5.5)	3.130	0.077	61 (4.2)	114 (5.6)	3.511	0.061
MRD	230 (6.6)	57 (4.6)	173 (7.8)	13.381	<0.001	106 (7.3)	124 (6.1)	1.984	0.159
AR	1876 (53.9)	639 (51.1)	1237 (55.5)	6.432	0.011	644 (44.4)	1232 (60.7)	90.122	<0.001
Asthma	376 (10.8)	96 (7.7)	280 (12.6)	19.939	<0.001	185 (12.8)	191 (9.4)	9.862	0.002
Total‡	3244 (93.3)	1119 (89.4)	2125 (95.4)	45.52	<0.001	1346 (92.9)	1898 (93.5)	0.573	0.449

Data are expressed as numbers (percentages).
*Middle-aged adults, ≥45 to <60 years old.
†Older adults, ≥60 years old.
‡Total is a multimorbid state with the existence of any one chronic disease.
AR, arthritis or rheumatism; ENP, emotional, nervous or psychiatric; MRD, memory-related disease.

analysis using three models with varying degrees of covariate adjustment. We checked model assumptions for all the analyses. Participants with missing data were omitted from the analysis. All statistical analyses were conducted using IBM SPSS V.20. Two-sided p<0.05 were considered statistically significant.

RESULTS

Among the 3478 participants aged 45–92 years (mean age 63.06 years, SD, 9.88; 41.7% men) in this study, 36% (n=1251) were middle aged (≥45 to<60 years) and 64% (n=2227) were older than 60 years.

CVD multimorbidity

Among the 12 chronic diseases, the number of comorbidities with CVD ranged from 0 to 11; median (IQR) values were 3 (2, 4) for all adults, 2 (1, 4) for middle-aged adults and 3 (2, 4) for older adults. In total, 17.1% (n=594) of the participants with CVD had only one comorbid chronic disease, 22.3% (n=777) had two comorbid chronic diseases and 21.4% (n=746) had three comorbid chronic diseases; 16.6% (n=579), 9.1% (n=316), 3.9% (n=137), 1.6% (n=57) and 1.1% (n=38) of participants with CVD had 4, 5, 6, 7 and 8 comorbid chronic diseases, respectively.

Table 1 lists the age and sex distribution of the 12 chronic diseases among adults with CVD. The proportion of participants with CVD who had multimorbidity was 93.3%, (89.4% for middle-aged adults and 95.4% for older adults, 92.9% for men and 93.5% for women). The proportions of multimorbidity were higher in older adults than in the middle-aged adults (χ^2=45.52, p<0.001), but there was no significant difference by sex (χ^2=0.573, p=0.449). Hypertension (56.1%), AR (53.9%) and digestive diseases (41.5%) were the top three chronic disease comorbidities with CVD. Compared with middle-aged adults who had CVD, older adults had significantly higher proportions of multimorbidity involving hypertension (χ^2=39.929, p<0.001), hyperglycaemia (χ^2=12.997, p<0.001), chronic lung disease (χ^2=36.396, p<0.001), MRD (χ^2=13.381, p<0.001), AR (χ^2=6.432, p<0.001) and asthma (χ^2=19.939, p<0.001). Compared with men, women had lower proportions of multimorbidity with hypertension (χ^2=6.286, p=0.003), chronic lung disease (χ^2=5.449, p=0.02), kidney disease (χ^2=8.6, p<0.001) and asthma (χ^2=9.862, p=0.002), and higher proportions with cancer (χ^2=10.806, p=0.001), digestive disease (χ^2=44.906, p<0.001) and AR (χ^2=90.122, p<0.001).

Age-specific and sex-specific proportions of multimorbidity and summed proportions of multimorbidity in participants with CVD are shown in figure 1. Most common was three comorbid chronic diseases in older adults with multimorbidity (22.9%), followed by two comorbid chronic diseases in middle-aged adults with multimorbidity (22.6%), shown in figure 1A. Older participants had significantly higher summed proportions of multimorbidity with more than one chronic disease (figure 1C). The proportion of multimorbidity with only one chronic disease in men was significantly higher than that in women (χ^2=7.283,

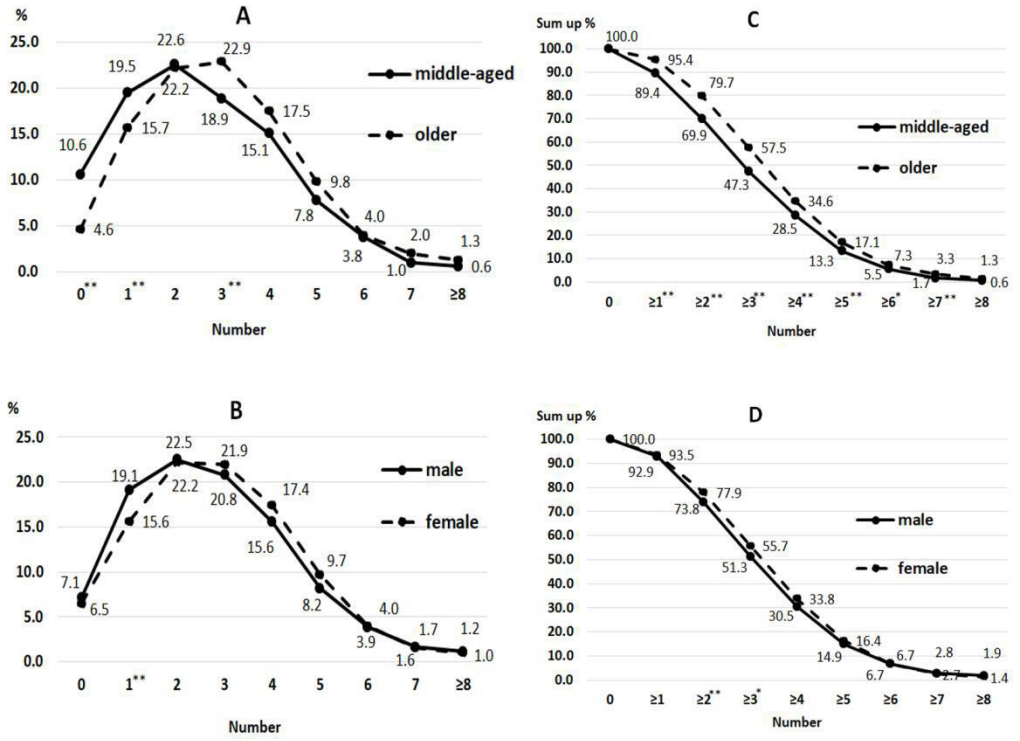

Figure 1 Proportion of multimorbidity with the indicated number of comorbidities grouped by age (A) and sex (B). Summed proportions of multimorbidity with the indicated number of comorbidities grouped by age (C) and sex (D). All participants had cardiovascular disease (*p<0.05, **p<0.01).

p=0.007) (figure 1B). However, the summed proportion of multimorbidity with two (χ^2=6.632, p=0.01) and three (χ^2=4.093, p=0.043) chronic diseases in men was significantly lower than that in women (χ^2=6.632, p=0.01) (figure 1D). The number of comorbidities accompanying CVD increased with age in both men and women among middle-aged adults (*F*=5.123, p<0.001) and older adults (*F*=5.123, p<0.001).

Association of CVD multimorbidity with life satisfaction

The proportion of all participants who were dissatisfied with life was 10.9%. The proportion of life dissatisfaction among participants with CVD and without multimorbidity was 6.4%, and this was 11.2% among their counterparts with multimorbidity, with significant differences (χ^2=5.147, p=0.023). The mean number of comorbidities was 2.76 (SD, 1.67) among participants who were satisfied with their life and 3.31 (SD, 1.87) among those who were dissatisfied with their life; this difference was significant (p<0.001). We also compared life satisfaction among different numbers of chronic disease comorbidities with CVD. We found a significant association of decreased life satisfaction with increased number of comorbid diseases (figure 2A). The same sequences were found in both men and women (figure 2B) and both middle-aged and older adults (figure 2C).

We also analysed the association of sex, number of chronic diseases comorbid with CVD and life satisfaction (table 2, model 1), and the association of age, number of chronic diseases comorbid with CVD and life satisfaction (table 2, model 2). In model 1, the interaction of sex and number of chronic diseases comorbid with CVD was not statistically significant(p=0.580). After removing the interaction, no significant difference was found in life satisfaction between male and female sex (OR=1.179, 95% CI: 0.945 to 1.472). The association of number of chronic diseases comorbid with CVD and life satisfaction was significant, with p<0.001. Compared with no chronic disease comorbidity with CVD, with four CVD multimorbidities, the association with life satisfaction was significant, with OR=1.992 (95%CI 1.116 to 3.558). The strength of the association was larger with the increased number of CVD multimorbidities. The same trend for the association of the number of chronic disease comorbidities with CVD and life satisfaction was found in model 2. In model 2, the interaction of age and number of chronic disease comorbidities with CVD was not statistically significant (p=0.392). After removing the interaction, age (OR=0.721, 95% CI 0.578 to 0.899)) and number of chronic disease (p<0.001) comorbidities with CVD and life satisfaction were both significant.

The association of one chronic disease (and only one chronic disease) comorbidity with CVD was assessed via logistic regression analysis, either unadjusted (model 1) or adjusted for covariates (models 2 and 3) (table 3). Three comorbidities were significantly associated with reduced life satisfaction in model 3: kidney disease

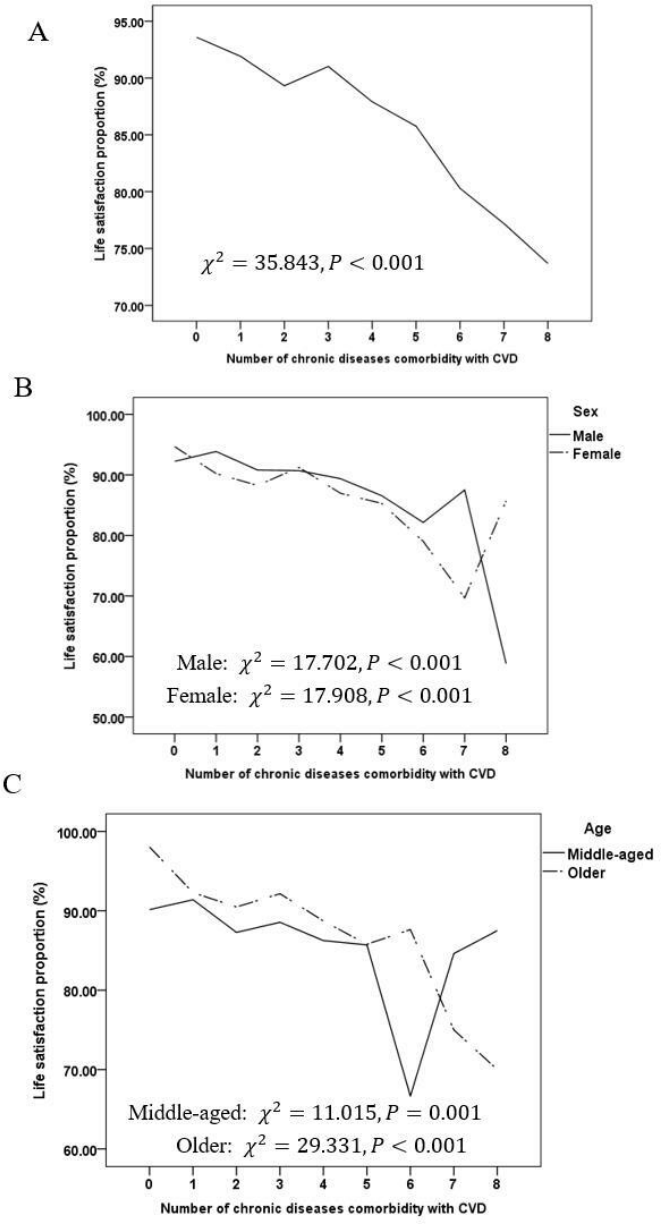

Figure 2 Life satisfaction among participants with different numbers of chronic diseases comorbid with cardiovascular disease (A) and sex-specific (B) and age-specific (C) associations.

(OR=1.933, 95% CI 1.483 to 2.521), MRD (OR=1.695, 95% CI 1.149 to 2.501) and dyslipidaemia (OR=1.346, 95% CI 1.048 to 1.729). Life satisfaction differed between middle-aged adults and older adults and between men and women (figure 3).

DISCUSSION

Summary

This analysis was based on the complete national population of China, using data of the CHARLS 2015. In this large cross-sectional study of a nationally representative sample, we found that CVD multimorbidity is highly prevalent in China. Although primarily associated with older adults, multimorbidity also occurs in a substantial number of middle-aged adults.[20]

In our study, we found that life satisfaction in patients with CVD decreased as the number of comorbidities with other chronic diseases increased. For older adults, we found that CVD with three or more comorbidities was more prevalent.

This study showed that kidney disease, dyslipidaemia and MRD were significantly correlated with reduced life satisfaction. These associations were independent of age, sex, marital status, place of residence, smoking, alcohol consumption, social activity, older age insurance, health insurance, sleep duration and nap duration. Our study emphasises the importance of preventing of chronic diseases in adults with CVD.

We found that the median number of comorbidities in older adults was three and two in middle-aged adults. The number of comorbidities increased with age in both men and women.

As a novel finding, our study revealed that the summed proportion of multimorbidity of two and three chronic diseases in women was significantly higher than those in men. Reasons for this difference include the higher exposure of women to common risk factors for chronic diseases and sex inequality in terms of access to healthcare.[21]

To the best of our knowledge, this is the first nationally representative analysis of the association of CVD multimorbidity with life satisfaction. This study revealed that 11.2% of participants with CVD multimorbidity were dissatisfied with their life, which was significantly higher than the proportion in those without other chronic diseases. The proportion of adults who were satisfied with their life decreased as the number of comorbidities increased, which was in line with the findings of previous studies.[22 23] The same trend was found in both men and women and both middle-aged adults and older adults. We also found that with four and more chronic disease comorbidities with CVD four and more, the risk of life dissatisfaction was significantly higher than with no CVD comorbidities. A heavy treatment burden and poor prognosis may be important reasons for this result.[24] Another interesting finding was that the risk of life dissatisfaction with each number of CVD multimorbidities was higher in middle-aged adults than older adults. Age reportedly negatively associated with life satisfaction.[25] Old age is associated with higher levels of happiness and life satisfaction, which is in line with our results.[26] Taken together, these studies as well as our findings underscore the importance of preventing multiple chronic diseases in patients with CVD, especially middle-aged adults, as a simple way to promote life satisfaction.

The most important finding was that 3 (dyslipidaemia, kidney disease and MRD) of 12 chronic diseases were significantly correlated with reduced life satisfaction. Kidney disease could significantly increase the risk of life dissatisfaction by 193.3% for all participants, followed by dyslipidaemia (OR=1.346) and MRD (OR=1.695). Kidney disease is also the only single chronic disease that showed

Table 2 Association of the number of multimorbid conditions in cardiovascular disease, sex (age) and life satisfaction

Model	Variables	No	B	P value	OR	95% CI
Model 1	Gender					
	Male	1449	Ref			
	Female	2029	0.165	0.144	1.179	0.945 to 1.472
	Number of CVD multimorbidity					
	n=0	234	Ref			
	n=1	594	0.254	0.407	1.289	0.707 to 2.351
	n=2	777	0.554	0.057	1.741	0.984 to 3.08
	n=3	746	0.359	0.225	1.432	0.802 to 2.559
	n=4	579	0.689	0.02	1.992	1.116 to 3.558
	n=5	316	0.876	0.005	2.401	1.303 to 4.423
	n=6	137	1.272	<0.001	3.568	1.823 to 6.985
	n=7	57	1.460	<0.001	4.305	1.914 to 9.682
	n=8	38	1.654	<0.001	5.227	2.142 to 12.756
Model 2	Age					
	Middle-aged	1251	Ref			
	Older	2227	−0.328	0.004	0.721	0.578 to 0.899
	Number of CVD multimorbidity			<0.001		
	n=0	234	Ref			
	n=1	594	0.300	0.328	1.350	0.739 to 2.465
	n=2	777	0.624	0.033	1.867	1.053 to 3.311
	n=3	746	0.448	0.132	1.565	0.873 to 2.805
	n=4	579	0.777	0.009	2.175	1.215 to 3.896
	n=5	316	0.972	0.002	2.643	1.43 to 4.885
	n=6	137	1.350	<0.001	3.859	1.966 to 7.574
	n=7	57	1.578	<0.001	4.846	2.144 to 10.954
	n=8	38	1.774	<0.001	5.897	2.404 to 14.465

a significant association with life satisfaction when only considering one chronic disease comorbidity with CVD. Previous reports emphasise the importance of improving the care of patients with CVD who have chronic kidney disease.[27] Reduced kidney function increases the risk of cardiovascular events and death,[28] and patients with both cardiovascular and kidney diseases have a higher risk of death than those with either alone.[29] The association of dyslipidaemia comorbidity with CVD and life satisfaction in women was higher than that in men, which is clinically noteworthy. Because dyslipidaemia is a prominent risk factor for CVD,[30] women with a history of CVD should maintain a low-density lipoprotein cholesterol level <100 mg/dL and preferably <70 mg/dL.[31] Treatment of dyslipidaemia is essential for preventing CVD.[32]

Comparison with existing literature

This study showed that more than half of older adults had multimorbidity with three chronic diseases and with two chronic diseases in more than half of middle-aged adults. This finding was in line with the results of a previous study.[14] The rate of CVD multimorbidity in China is 93.3%, and this is slightly higher in Northeast China (96.17%).[33]

In our study, as in other research,[34] the number of comorbidities increased with age in men and women. Whereas multimorbidity can develop at all ages, the number, complexity and diversity of comorbid conditions usually increase with advancing age.[35] This study showed that the proportion of men with CVD who had one chronic comorbid disease was higher than that of their female counterparts. However, although there was no significant difference, the proportion of women with CVD who had two and more comorbidities was higher than that in their male counterparts, which is in agreement with previous studies.[36 37]

In this study, we used a one-dimensional model to estimate life satisfaction. A one-dimensional model, measuring overall satisfaction in life with a single question, is commonly used in large-scale, nationwide surveys and international surveys, and this type of model has been proven to be credible and reliable.[38] Compared with a multidimensional model, one-dimensional model

Table 3 Association of chronic disease multimorbidity in cardiovascular disease and life satisfaction in China

	Model 1*				Model 2†				Model 3‡			
Outcome	**B**	**P value**	**OR**	**95% CI**	**B**	**P value**	**OR**	**95% CI**	**B**	**P value**	**OR**	**95% CI**
With chronic disease comorbidity												
Hypertension	−0.022	0.852	0.979	0.78 to 1.228	0.006	0.963	1.006	0.795 to 1.272	0.022	0.860	1.022	0.802 to 1.302
Dyslipidaemia	0.205	0.091	1.227	0.968 to 1.556	0.278	0.025	1.320	1.035 to 1.684	0.297	0.020	1.346	1.048 to 1.729
Hyperglycaemia	−0.243	0.113	0.784	0.58 to 1.059	−0.253	0.114	0.776	0.567 to 1.063	−0.262	0.110	0.770	0.558 to 1.061
Cancer	0.320	0.276	1.377	0.774 to 2.448	0.373	0.209	1.452	0.812 to 2.598	0.435	0.149	1.544	0.856 to 2.786
Lung disease	−0.023	0.869	0.977	0.742 to 1.286	−0.065	0.654	0.937	0.705 to 1.245	−0.09	0.549	0.914	0.682 to 1.226
Liver disease	0.009	0.955	1.009	0.73 to 1.395	0.010	0.955	1.010	0.725 to 1.407	−0.067	0.703	0.936	0.664 to 1.318
Kidney disease	0.652	<0.001	1.920	1.492 to 2.47	0.668	<0.001	1.950	1.505 to 2.527	0.659	<0.001	1.933	1.483 to 2.521
Digestive disease	0.224	0.054	1.251	0.996 to 1.572	0.192	0.107	1.212	0.959 to 1.532	0.154	0.211	1.166	0.916 to 1.485
ENP disorder	0.55	0.007	1.734	1.159 to 2.593	0.451	0.038	1.570	1.025 to 2.404	0.343	0.131	1.409	0.903 to 2.199
MRD	0.458	0.015	1.581	1.093 to 2.286	0.551	0.004	1.736	1.189 to 2.533	0.528	0.008	1.695	1.149 to 2.501
AR	0.209	0.077	1.233	0.977 to 1.555	0.179	0.144	1.196	0.941 to 1.519	0.089	0.480	1.093	0.854 to 1.401
Asthma	0.179	0.331	1.196	0.834 to 1.716	0.270	0.154	1.31	0.904 to 1.898	0.268	0.168	1.307	0.893 to 1.912
With only one chronic disease comorbidity												
Hypertension	−0.331	0.315	0.718	0.376 to 1.37	−0.244	0.474	0.784	0.402 to 1.528	−0.319	0.385	0.727	0.354 to 1.493
Dyslipidaemia	−0.701	0.343	0.496	0.116 to 2.112	−0.654	0.379	0.520	0.121 to 2.235	−0.685	0.362	0.504	0.115 to 2.199
Hyperglycaemia	−18.803	0.998	0.000	0 to 0	−18.542	0.998	0.000	0 to 0	−18.399	0.999	0.000	0 to 0
Cancer	1.348	0.247	3.851	0.393 to 37.753	1.477	0.209	4.381	0.437 to 43.9	2.068	0.100	7.912	0.674 to 92.853
Lung disease	0.248	0.693	1.281	0.374 to 4.389	0.413	0.517	1.512	0.433 to 5.276	0.543	0.402	1.722	0.483 to 6.139
Liver disease	−18.786	0.999	0.000	0 to 0	−19.049	0.999	0.000	0 to 0	−18.804	0.999	0.000	0 to 0
Kidney disease	1.486	0.014	4.421	1.352 to 14.46	1.357	0.041	3.883	1.058 to 14.244	1.431	0.036	4.182	1.098 to 15.929
Digestive disease	0.124	0.760	1.132	0.511 to 2.505	0.157	0.719	1.170	0.497 to 2.755	0.256	0.568	1.292	0.536 to 3.118
ENP disorder	−18.777	0.999	0.000	0 to 0	−18.453	0.999	0.000	0 to 0	−18.224	0.999	0.000	0 to 0
MRD	−18.781	0.999	0.000	0 to 0	−18.418	0.999	0.000	0 to 0	−18.264	0.999	0.000	0 to 0
AR	0.372	0.248	1.450	0.772 to 2.723	0.223	0.506	1.250	0.648 to 2.412	0.121	0.733	1.129	0.563 to 2.265
Asthma	−18.784	0.999	0.000	0 to 0	−18.847	0.999	0.000	0 to 0	−18.639	0.999	0.000	0 to 0

*Not adjusted for covariates.
†Adjusted for age, sex, marital status and place of residence.
‡Adjusted for the covariates in model 2 plus smoking, alcohol consumption, social activity, older age insurance, health insurance, sleep duration and nap duration.
AR, arthritis or rheumatism; ENP, emotional, nervous or psychiatric; MRD, memory-related disease.

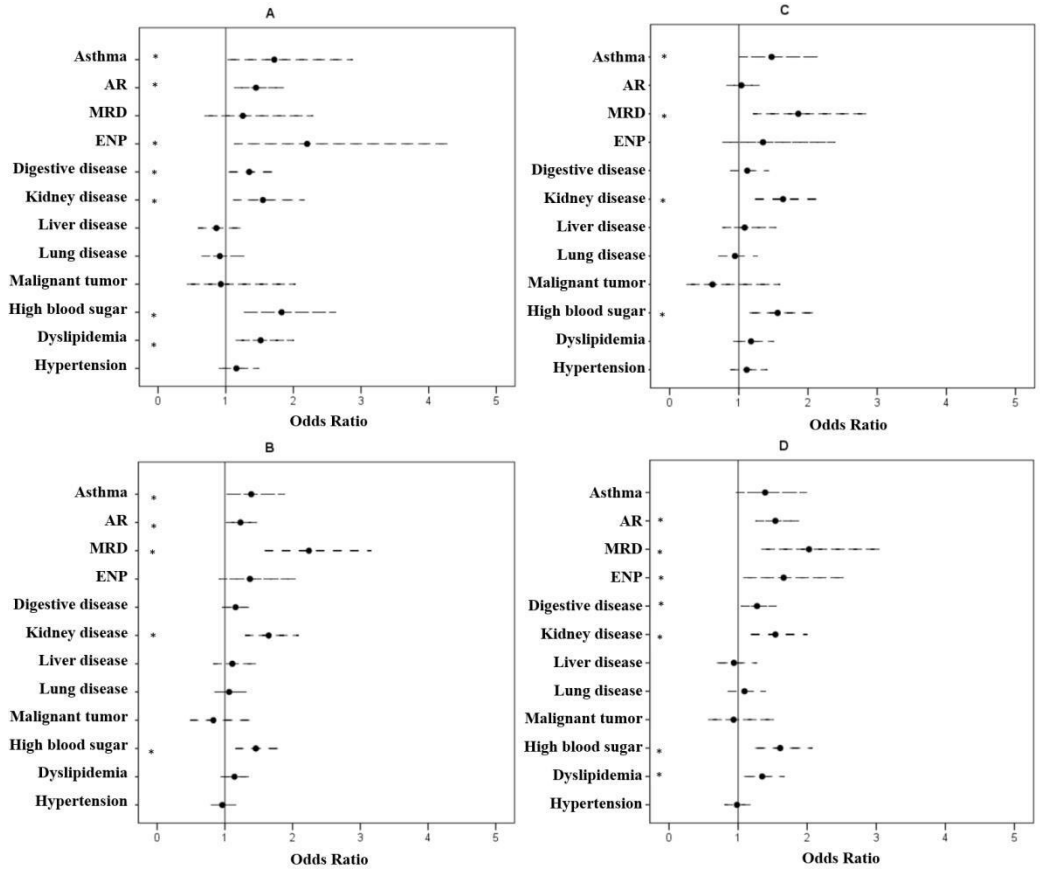

Figure 3 Association of cardiovascular disease multimorbidity with life satisfaction grouped by age (A: middle-aged adults, B: older adults) and sex (C: men, D: women). ORs were calculated after adjusting for age, sex, marital status, place of residence, smoking, alcohol consumption, social activity, older age insurance, health insurance, sleep duration and nap duration (*p<0.05). AR, arthritis or rheumatism; ENP, emotional, nervous or psychiatric; MRD, memory-related disease.

is based on the perception of general satisfaction with life rather than life satisfaction with respect to certain aspects. One-dimensional model of life satisfaction had been shown to effectively predict mortality, hospitalisation and overall health.[39]

Our previous study pointed that comorbidity with CVD and depression could significantly increase the risk of MRD.[40] We revealed in this study that the comorbidity of CVD and MRD could significantly increase the risk of life dissatisfaction by 169.5%. Although a previous study reported a significant positive relationship between subjective memory and overall well-being in older adults,[41] our study was the first to investigate the association of MRD comorbidity with CVD and lower life satisfaction.

Limitations

Although this study is a representative sample of China, some limitations remain. First, chronic diseases including CVD were all self-reported, which has been proven to have poor sensitivity but good specificity and positive predictive values[42] but might nevertheless be prone to information error. Second, the data were obtained from a nationwide CHARLS survey. Only a single question was used to measure overall life satisfaction among individuals with different occupations.[43 44] This approach does not allow us to develop a more comprehensive understanding of which area of life respondents are dissatisfied with.[45] As this is a cross-sectional study, only association of life satisfaction and chronic disease comorbidity in CVD could be revealed. Although 11 covariates were adjusted, several others were not included, such as personality and economic confounders.

Implications for research and practice

CVD multimorbidity is prevalent among middle-aged adults and older adults in China, which is a major public health concern. The high prevalence of CVD multimorbidity may reflect the age-related decline in immune function, and hence the increased vulnerability of older adults and middle-aged adults to chronic diseases.[45] We also investigated whether life satisfaction declined when chronic disease comorbidity with CVD increased; we found that this decline was worse for middle-aged adults than older adults. This calls attention to the importance of preventing of other chronic diseases among middle-aged adults with CVD and not only their older counterparts.

Our study showed that dyslipidaemia, kidney disease and MRD were significantly associated with reduced life satisfaction, independent of age, sex, marital status, place of residence, smoking, alcohol consumption, social activity, older age insurance, health insurance, sleep duration and nap duration. Although we were unable to

determine a causal link between CVD multimorbidity and reduced life satisfaction, our findings regarding this association are valuable. Life satisfaction is not only a measure of health and quality of life but also a reflection of hope and confidence in life.[46 47]

Our study emphasises the importance of preventing of chronic diseases in adults with CVD. Prevention and treatment of chronic disease comorbidity in CVD warrants further research in prospective cohort studies or clinical trials. Future research should further explore the issues associated with or responsible for higher levels of life satisfaction among older adults with CVD and comorbid kidney disease, dyslipidaemia and MRD.

Acknowledgements We thank the participants and staff of the China Health and Retirement Longitudinal Study (CHARLS) team for their valuable contributions.

Collaborators Not Applicable.

Contributors GL, YX and QG designed and performed the research study. GL, YX and YL wrote original draft, curation data. YX analysed the data. YL and SW performed formal analysis and provided comments. QG performed conceptualisation and methodology, accessed to funds, provided guidance and comments. These authors critically revised the manuscript and agreed to the final version.

Funding This work was supported by the Medical Scientific Research Foundation of Guangdong Province of China (grant number A2020008), the High-level Hospital Construction Project of Guangdong Provincial People's Hospital of China (grant number DFJH201811 and KJ012019431) and the Scientific Research Foundation of Health Economics Association of Guangdong Province of China (grant number 2019-WJMF-02 and 2020-WJZD-12).

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Obtained.

Ethics approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Ethics approval for data collection in the CHARLS was obtained from the Biomedical Ethics Review Committee of Peking University (IRB00001052-11015).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

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REFERENCES

1 Jiang XQ, Du P. *Report on China's population ageing and the elderly welfare facilities*, 2015.
2 Forman DE, Rich MW, Alexander KP, *et al*. Cardiac care for older adults. Time for a new paradigm. *J Am Coll Cardiol* 2011;57:1801–10.
3 Tinetti ME, Fried TR, Boyd CM. Designing health care for the most common chronic condition--multimorbidity. *JAMA* 2012;307:2493–4.
4 WHO. Health topics. Available: http://www.who.int/en/; http://www.who.int/topics/ cardiovascular_diseases/en/
5 LY M, YZ W, Wang W, *et al*. Interpretation of the report on cardiovascular diseases in China (2017). *Chin J Cardiovasc Med* 2018;23:3–6.
6 Kleipool EE, Hoogendijk EO, Trappenburg MC, *et al*. Frailty in older adults with cardiovascular disease: cause, effect or both? *Aging Dis* 2018;9:489–97.
7 Liu J, Ma J, Wang J, *et al*. Comorbidity analysis according to sex and age in hypertension patients in China. *Int J Med Sci* 2016;13:99–107.
8 Wenger NK, Doherty CL, Gurwitz JH, *et al*. Optimization of drug prescription and medication management in older adults with cardiovascular disease. *Drugs Aging* 2017;34:803–10.
9 Lehrke M, Marx N. Diabetes mellitus and heart failure. *Am J Med* 2017;130:S40–50.
10 Mendis S, Puska P, Norrving B. *Global atlas on cardiovascular disease prevention and control*. Geneva: World Health Organization, 2011.
11 Lavie CJ, McAuley PA, Church TS, *et al*. Obesity and cardiovascular diseases: implications regarding fitness, fatness, and severity in the obesity paradox. *J Am Coll Cardiol* 2014;63:1345–54.
12 Shad B, Ashouri A, Hasandokht T, *et al*. Effect of multimorbidity on quality of life in adult with cardiovascular disease: a cross-sectional study. *Health Qual Life Outcomes* 2017;15:240.
13 Violán C, Bejarano-Rivera N, Foguet-Boreu Q, *et al*. The burden of cardiovascular morbidity in a European Mediterranean population with multimorbidity: a cross-sectional study. *BMC Fam Pract* 2016;17:150.
14 Dunlay SM, Chamberlain AM. Multimorbidity in older patients with cardiovascular disease. *Curr Cardiovasc Risk Rep* 2016;10:1–9.
15 Dong H-J, Larsson B, Dragioti E, *et al*. Factors associated with life satisfaction in older adults with chronic pain (PainS65+). *J Pain Res* 2020;13:475–89.
16 Rosella LC, Fu L, Buajitti E, *et al*. Death and chronic disease risk associated with poor life satisfaction: a population-based cohort study. *Am J Epidemiol* 2019;188:323–31.
17 Calderón-Larrañaga A, Vetrano DL, Welmer A-K, *et al*. Psychological correlates of multimorbidity and disability accumulation in older adults. *Age Ageing* 2019;48:789–96.
18 Zhao Y, Hu Y, Smith JP, *et al*. Cohort profile: the China Health and Retirement Longitudinal Study (CHARLS). *Int J Epidemiol* 2014;43:61–8.
19 Wang XD, Wang XL. *Manual on mental health assessment*. 2nd edn. Chinese Magazine Agency of Mental Health, 1999: 75–9.
20 Barnett K, Mercer SW, Norbury M, *et al*. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *Lancet* 2012;380:37–43.
21 Wang SB, D'Arcy C, Yu YQ, *et al*. Prevalence and patterns of multimorbidity in northeastern China: a cross-sectional study. *Public Health* 2015;129:1539–46.
22 Ge L, Ong R, Yap CW, *et al*. Effects of chronic diseases on health-related quality of life and self-rated health among three adult age groups. *Nurs Health Sci* 2019;21:214–22.
23 Marques A, Peralta M, Martins J, *et al*. Cross-sectional and prospective relationship between physical activity and chronic diseases in European older adults. *Int J Public Health* 2017;62:495–502.
24 Steeves JA, Shiroma EJ, Conger SA, *et al*. Physical activity patterns and multimorbidity burden of older adults with different levels of functional status: NHANES 2003-2006. *Disabil Health J* 2019;12:495–502.
25 Huang H, Liu S, Sharma A, *et al*. Factors associated with life satisfaction among married women in rural China: a cross-sectional study based on large-scale samples. *Psychol Res Behav Manag* 2018;11:525–33.
26 Grundy E, Murphy M. Coresidence with a child and happiness among older widows in Europe: does gender of the child matter? *Popul Space Place* 2018;24:e2102–e2102.13.
27 Glynn LG, Reddan D, Newell J, *et al*. Chronic kidney disease and mortality and morbidity among patients with established cardiovascular disease: a west of Ireland community-based cohort study. *Nephrol Dial Transplant* 2007;22:2586–94.
28 Sarnak MJ, Levey AS, Schoolwerth AC, *et al*. Kidney disease as a risk factor for development of cardiovascular disease: a statement from the American Heart Association Councils on Kidney in Cardiovascular Disease, High Blood Pressure Research, Clinical Cardiology, and Epidemiology and Prevention. *Circulation* 2003;108:2154–69.
29 McCullough PA, Steigerwalt S, Tolia K, *et al*. Cardiovascular disease in chronic kidney disease: data from the Kidney Early Evaluation Program (KEEP). *Curr Diab Rep* 2011;11:47–55.

30 Yusuf S, Hawken S, Ounpuu S, *et al*. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *Lancet* 2004;364:937–52.
31 National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III) final report. *Circulation* 2002;106:3143–421.
32 Whelton S, Chow GV, Ashen D, *et al*. Dyslipidemia management for secondary prevention in women with cardiovascular disease: what can we expect from non-pharmacologic strategies? *Curr Cardiovasc Risk Rep* 2012;6:443–9.
33 Vetrano DL, Foebel AD, Marengoni A, *et al*. Chronic diseases and geriatric syndromes: the different weight of comorbidity. *Eur J Intern Med* 2016;27:62–7.
34 Ahmadi B, Alimohammadian M, Yaseri M, *et al*. Multimorbidity: epidemiology and risk factors in the Golestan Cohort Study, Iran: a cross-sectional analysis. *Medicine* 2016;95:e2756.
35 Forman DE, Maurer MS, Boyd C, *et al*. Multimorbidity in older adults with cardiovascular disease. *J Am Coll Cardiol* 2018;71:2149–61.
36 Alimohammadian M, Majidi A, Yaseri M, *et al*. Multimorbidity as an important issue among women: results of a gender difference investigation in a large population-based cross-sectional study in West Asia. *BMJ Open* 2017;7:e013548.
37 Puth M-T, Weckbecker K, Schmid M, *et al*. Prevalence of multimorbidity in Germany: impact of age and educational level in a cross-sectional study on 19,294 adults. *BMC Public Health* 2017;17:826.
38 Appleton S, Song L. Life satisfaction in urban China: components and determinants. *World Dev* 2008;36:2325–40.
39 Idler EL, Benyamini Y. Self-rated health and mortality: a review of twenty-seven community studies. *J Health Soc Behav* 1997;38:21–37.
40 Xue Y, Liu G, Geng Q. Associations of cardiovascular disease and depression with memory related disease: a Chinese national prospective cohort study. *J Affect Disord* 2020;260:11–17.
41 Toffalini E, Borella E, Cornoldi C, *et al*. The relevance of memory sensitivity for psychological well-being in aging. *Qual Life Res* 2016;25:1943–8.
42 Yuan X, Liu T, Wu L, *et al*. Validity of self-reported diabetes among middle-aged and older Chinese adults: the China Health and Retirement Longitudinal Study. *BMJ Open* 2015;5:e006633.
43 Yang L, Weng X, Subramanian SV. Associations between older adults' parental bereavement and their health and well-being: evidence from the China Health and Retirement Longitudinal Study. *J Affect Disord* 2020;272:207–14.
44 Ouyang P, Sun W, Wang C. Well-being loss in informal care for the elderly people: empirical study from China national baseline CHARLS. *Asia Pac Psychiatry* 2019;11:e12336.
45 Liang Y, Lu P. Effect of occupational mobility and health status on life satisfaction of Chinese residents of different occupations: logistic diagonal mobility models analysis of cross-sectional data on eight Chinese provinces. *Int J Equity Health* 2014;13:15.
46 Salisbury C. Designing health care for the people who need it: James MacKenzie Lecture 2018. *Br J Gen Pract* 2019;69:458–9.
47 Azuero A, Williams CP, Pisu M, *et al*. An examination of the relationship between patient satisfaction with healthcare and quality of life in a geriatric population with cancer in the southeastern United States. *J Geriatr Oncol* 2019;10:787–91.