The Disease Burden Morbidity Assessment in older adults and its association with mortality and other health outcomes

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Published online: 1 November 2018
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Abstract

The objective of this study was to assess how disease burden caused by chronic conditions is related to mortality (predictive validity) and other health outcomes (convergent validity). This was studied in 625 community-dwelling adults living in Spain aged 65 years and older. Disease burden was measured with the Disease Burden Morbidity Assessment (DBMA). The association with 5-year mortality was assessed using a Cox model and Kaplan–Meier curves. For convergent validity, mean age, sex ratio, patient-centered outcomes and healthcare utilization were compared for high and low DBMA scores (< 10 vs. ≥ 10). Also, a multivariable linear regression model was used to evaluate the DBMA as a function of these variables. Mean DBMA score in our sample was 7.5. After 5 years, 35 participants had died (5.5%). The Cox model displayed a hazard ratio of 1.07, and the Kaplan–Meier curves showed lower survival for high DBMA scores. Among participants with high DBMA scores, low self-perceived health, disability and female sex were more frequent, and this group showed lower mean scores for quality of life (Personal Wellbeing Index), affect balance (Scale of Positive and Negative Experience) and physical activity (Yale Physical Activity Survey), higher mean age and higher healthcare utilization than persons with low DBMA scores. In the multivariable regression, all variables but age were significantly associated with the DBMA. In conclusion, the DBMA showed satisfactory predictive and convergent validity. In our aging society, it can be applied to better understand and improve care for older persons with multiple chronic conditions.

Keywords Comorbidity · Health status · Burden of illness · Chronic disease · Aged

Introduction

Worldwide, healthcare systems are facing the challenges induced by population aging. The vast majority of older people present with simultaneous chronic conditions. Multimorbidity is defined by the World Health Organization as the simultaneous presence of two or more chronic conditions in the population (World Health Organization 2008). This

Responsible editor: D.J.H. Deeg.

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s10433-018-0491-2>) contains supplementary material, which is available to authorized users.

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term is complementary of the term comorbidity, used when the focus is put on a given index disease (Newman 2012). Although both terms are frequently used interchangeably, in this study we specifically use the term multimorbidity.

Multimorbidity is a highly prevalent health problem, frequently associated with decreased quality of life (QoL) and functional status, and increased healthcare utilization, complications of treatment and mortality (Marengoni et al. 2011; Barnett et al. 2012; Wallace et al. 2015; Forjaz et al. 2015). There are different tools to assess multimorbidity, and the choice of an instrument depends on the type of data available, study population and specific outcome of interest (Yurkovich et al. 2015). The Charlson Comorbidity Index (CCI) is the most widely used tool for comorbidity assessment (Charlson et al. 1987). It contains 17 disease categories, each with an associated weight based on the associated risk of mortality. This index was initially developed to predict 1-year mortality after hospitalization and was later validated to predict longer-term mortality, disability, hospital length of stay and readmissions (Bayliss et al. 2005). Another frequently applied comorbidity index is the Elixhauser's Comorbidity Measure (ECM) (Elixhauser et al. 1998), which defines 30 comorbidity groups and was validated to predict in-hospital mortality, length of stay and hospital costs using administrative data. Many of the outcomes the CCI and the ECM were found to predict, can be expressed in healthcare costs and can therefore be regarded as healthcare-system-centered outcomes (Mehta et al. 2016).

Bayliss et al. (2005) developed a multimorbidity assessment instrument that assesses disease burden from a patient-centered perspective. This tool was later denominated the Disease Burden Morbidity Assessment (DBMA) by Poitras et al. (2012). The DBMA evaluates the impact of chronic conditions on daily activities as a measure of disease severity. This outcome measure was conceptualized as self-reported disease burden. The DBMA showed higher correlations with patient-reported outcomes (overall health status, functional status, depression and self-efficacy) than the CCI (Bayliss et al. 2005).

The DBMA was designed and validated to be associated with QoL outcomes, unlike other multimorbidity assessment scales such as the CCI and ECM where mortality was one of the main outcomes of interest. However, patient-centered outcomes such as self-perceived health (Kaplan and Camacho 1983) and QoL (Brown et al. 2015; González-Vélez et al. 2015) are also known to be associated with mortality, so we could expect the DBMA, as a patient-centered measure that takes into account the presence of conditions, to be related to mortality as well.

Therefore, the main objective of this paper was to study the predictive validity of the DBMA, by assessing how self-perceived disease burden predicts 5-year mortality. This was done in a sample of community-dwelling older adults aged

65 years or more, living in Spain. As a secondary objective, we wanted to further appraise convergent validity of the DBMA with patient-centered outcomes, since this was what the scale was designed for. This was done by studying cross-sectional associations with self-perceived health, functional status, QoL, affect balance and physical activity. The use of healthcare resources was added in this analysis to assess convergent validity of the DBMA with healthcare-system-centered outcomes.

Methods

Study design and sample

The data used in this study came from the Ageing in Spain Longitudinal Study, Pilot Survey (ELES-PS) (Rodríguez-Laso et al. 2014). This study was conducted with community-dwelling adults aged 50 years or more, living in Spain. The sample design consisted of a national stratified multi-stage cluster, proportional to the weight of the population of persons aged 50 years or more in each regional stratum, although it contains an overrepresentation of the Basque Country.

The ELES-PS information was collected in four stages: a telephone questionnaire, a visit by a trained nurse, a Computer-Assisted Personal Interviewing (CAPI) questionnaire and a self-administered questionnaire. For the current study, persons aged 65 years or more were selected ($n=922$), of whom 707 persons completed the CAPI questionnaire, the part of the ELES-PS that included the variables of interest. Of these 707 persons, only those who completed the DBMA were included, resulting in a final sample of 625 persons. Due to missing values, the sample for the multivariate analysis consisted of 496 persons.

The data on mortality from all causes were obtained from the Spanish National Death Index, which includes all deaths registered in Spain since 1987. The exact follow-up time ranged 4.4–5.0 years, with a mean follow-up time of 4.7 years, due to the broad time span in which the CAPI interviews were performed. Persons were searched automatically and manually by full name, sex and date of birth. The register does not provide information about the cause of death, and only the date of death is provided.

Assessments

The CAPI questionnaire contained the DBMA, a multimorbidity assessment scale as described by Bayliss et al. (2005). In this scale, consisting of a list of chronic medical conditions, participants are asked for every condition whether they have it and, if so, to what extent it interferes with their everyday life on a scale from 1 (not at all) to 5 (a

lot). Non-present conditions are scored zero. The total score, obtained by summing the scores given to the different conditions, provides a measure of self-reported disease burden. We adapted the original list of conditions used by Bayliss et al. (2005) by selecting 21 common chronic conditions, based on their use in other multimorbidity indexes (Fried et al. 1999; Sangha et al. 2003; Bayliss et al. 2005; Groll et al. 2005; Byles et al. 2005). More detailed information may be found elsewhere (Wijers et al. 2017).

For self-perceived health, participants were asked to rate their general health on a scale from 1 (very bad) to 5 (very good). In the current study, this variable was dichotomized, into very good/good versus acceptable/poor/very poor (Fernandez-Martinez et al. 2012).

Functional status was assessed by a 24-item scale, as used in the Health and Retirement Study (Bendayan et al. 2016) consisting of basic and instrumental activities of daily living. Participants are asked whether they experience difficulties performing them on a scale from 1 (always) to never (4). Scores are summed for each individual, resulting in a scale from 24 to 96, and total scores of < 96 indicate the presence of any level of disability (Forjaz et al. 2015).

The Personal Wellbeing Index (PWI) was included for assessing global QoL (The International Wellbeing Group 2013). In the PWI, participants are asked to grade, on a 0–10 scale, their satisfaction with seven life dimensions: standard of living, personal health, achieving in life, personal relationships, personal safety, community connectedness and future security. Total scores were linearly transformed into a 0–100 scale, higher scores indicating better QoL (Forjaz et al. 2012).

To assess affect balance, the Scale of Positive and Negative Experience (SPANE) was used (Diener et al. 2009). This 12-item questionnaire includes six items to assess positive feelings (positive, good, pleasant, happy, joyful and contented) and six items for negative feelings (negative, bad, unpleasant, sad, afraid and angry). Respondents are asked to report how much they experienced each feeling in the past month, on a scale from 1 (very rarely or never) to 5 (very often or always). Scores for negative feelings are subtracted from the positive feeling total score, resulting in a total scale from –24 (unhappiest) to 24 (happiest).

The second part of the Yale Physical Activity Survey (YPAS) (Dipietro et al. 1993) was included in the CAPI questionnaire as a measure of physical activity. In this section, activities performed in the last month (vigorous activity, leisurely walking, moving around, standing and sitting) are scored by multiplying a frequency score by a duration score for each of the five specific activities and multiplying again by a weighting factor. Weights are based on the relative intensity of the activity. The five indices are summed to obtain the total score.

Three measures were included to assess healthcare utilization. To obtain a measure of primary care utilization, participants were asked for the number of visits to the primary care center (general practitioner, nurse) in the past month. Secondly, a question about the number of visits to the specialist in the past 3 months was added. Finally, to assess the use of hospital care resources, the visits to the emergency department, day hospital and hospital admissions in the past year were summed. In the present study, due to the small proportion of hospital use, the last two measures (visits to the specialist and hospital care) were combined in order to get a measure of secondary/tertiary care. Both healthcare utilization measures were dichotomized into use versus no use of primary and secondary/tertiary healthcare resources.

Ethical issues

The ELES-PS study was approved by the Ethics Committee of the Spanish National Research Council. Informed consent was obtained from all individual participants included in the study. Since obtaining mortality data from the Spanish National Death Index was not among the initial objectives of the ELES study, a second approval was obtained from the Ethics Committee of the Carlos III Institute of Health for this particular part of the current study.

Statistical analyses

Due to overrepresentation of a Spanish region (the Basque Country) in the sample, analyses were weighted according to the underlying population distribution and accounted for the effect of stratification and clustering.

Predictive validity: mortality

We used the Cox proportional hazards model to examine the relation between the DBMA, as a continuous variable, and mortality. First, a model with only age and sex was tested, and after that, the disease burden variable was added. The proportional hazards assumption was confirmed graphically. In addition, a comparison of survival between high (≥ 10) and low (< 10) DBMA scores was made using Kaplan–Meier curves. The cutoff point of 10 was proposed by Haggerty et al. (2010) to be used as a cutoff point for multimorbidity, since it may correspond to patients with either several chronic conditions with minimal impact or minimal two conditions that cause maximal disease burden (Mokraoui et al. 2016). The Kaplan–Meier analysis does not allow correcting for complex samples, so only the weights were taken into account. The expected survival rate in our sample, calculated with national mortality data 2013 for the Spanish general population, (Instituto Nacional de Estadística 2014), was added to this graph.

Convergent validity: patient-centered outcomes and healthcare utilization

For patient-centered outcomes (self-perceived health, functional status, QoL, affect balance and physical activity), utilization outcomes (primary and secondary/tertiary care utilization), age and sex, we first studied the differences between patients with high and low DBMA scores (< 10 vs. ≥ 10). p values for the differences found in this analysis were obtained through Chi-square tests in case of dichotomic variables and through Somers' D analyses (Newson 2001) weighted for the population distribution in case of continuous variables, since Wilcoxon rank-sum tests do not allow weights or correction for complex design.

We used bivariate regression models to determine which of the patient-centered and utilization outcomes should be included in the multivariable linear regression model. Independent variables significant at a $p \leq 0.15$ level were considered for inclusion (Bayliss et al. 2009). Because of the skewed distribution of the DBMA in our sample (Fig. 1), a generalized linear model (glm) with gamma distribution and log link was used for these bivariate and multivariable

regression models (MVR), in order to be able to use the DBMA as a continuous variable.

Results

Table 1 presents the descriptive statistics of socio-demographic variables and applied rating scales, as well as a column describing Spanish national data. Mean age was 74.2 years (standard error SE = 0.3) for the total sample of persons aged 65 years and older, 73.9 years (SE = 0.4) for participants that answered the DBMA and 73.7 years (SE = 0.4) for the persons included in the MVR. The proportion of women in these three groups was 57.1, 55.4 and 53.0%, respectively. Mean DBMA score was 7.5 (SE = 0.4) for both the total sample aged ≥ 65 years and the persons who answered the DBMA, and 7.4 (SE = 0.4) for the MVR sample. When considering multimorbidity as the presence of two or more chronic conditions in one person, 76.1, 74.8 and 73.0% of the participants were multimorbid in the three different samples, respectively. These proportions were 56.6, 54.6 and 52.6% for the presence of three chronic conditions,

Fig. 1 Range of DBMA scores among respondents by sex, age groups, living/deceased and for the total sample ($n = 625$)

Table 1 Characteristics of the study sample: total sample aged 65 years and older, sample with complete DBMA data, sample included in the multivariable regression (MVR) and Spanish national data

Characteristic	Total sample aged ≥ 65 years (<i>n</i> = 707)		DBMA present (<i>n</i> = 625)		Sample MVR (<i>n</i> = 496)		National data ^b	
	<i>n</i> (%) ^a		<i>n</i> (%) ^a		<i>n</i> (%) ^a		<i>n</i> (%)	
Sex								
Men	304 (42.9)		280 (44.6)		234 (47.0)		234 (43.0)	
Women	403 (57.1)		345 (55.4)		262 (53.0)		262 (57.0)	
Education								
Less than primary	155 (23.4)		129 (21.8)		93 (19.9)		93 (37.0)	
Primary education	210 (28.5)		181 (28.0)		146 (28.5)		146 (27.7)	
Secondary education	220 (30.0)		199 (30.9)		158 (31.3)		158 (27.7)	
Higher education	122 (18.1)		116 (19.4)		99 (20.3)		99 (7.6)	
Living area								
< 10,000 inhabitants	133 (21.2)		125 (21.8)		102 (22.1)		102 (25.3)	
10,000–100,000	273 (36.5)		237 (35.4)		182 (34.3)		182 (34.0)	
100,000–500,000	201 (24.1)		165 (23.3)		136 (25.1)		136 (22.7)	
> 500,000 inhabitants	100 (18.2)		98 (19.5)		76 (18.6)		76 (17.9)	
Marital status								
Single/living with partner	33 (5.1)		31 (5.3)		24 (5.3)		24 (7.4)	
Married	437 (60.6)		392 (60.7)		324 (63.3)		324 (60.5)	
Widowed	211 (30.1)		179 (29.7)		132 (27.8)		132 (29.0)	
Divorced/separated	26 (4.3)		23 (4.2)		16 (3.7)		16 (3.2)	
Self-perceived health								
Very good/good	378 (53.9)		353 (57.4)		295 (57.2)		295 (44.2)	
Acceptable/poor/very poor	301 (46.1)		262 (42.6)		201 (42.8)		201 (55.8)	
Missing ^c	28		10					
Functional status								
No disability	263 (38.6)		249 (41.8)		218 (43.3)		218 (43.3)	
Disability	408 (61.4)		347 (58.2)		278 (56.7)		278 (56.7)	
Missing ^c	36		29					
Primary/outpatient care past month								
Yes	458 (67.3)		405 (67.3)		326 (67.9)		326 (67.9)	
No	249 (32.7)		220 (32.7)		170 (32.1)		170 (32.1)	
Hospital care past year								
Yes	190 (29.8)		171 (29.5)		137 (27.2)		137 (27.2)	
No	517 (70.2)		454 (70.5)		359 (72.4)		359 (72.4)	

Table 1 (continued)

Characteristic	Total sample aged ≥ 65 years (<i>n</i> = 707)		DBMA present (<i>n</i> = 625)		Sample MVR (<i>n</i> = 496)		National data ^b	
	<i>n</i> (%) ^a		<i>n</i> (%) ^a		<i>n</i> (%) ^a		(%)	
Multimorbidity								
< 2 conditions	191 (23.9)		182 (25.2)		150 (27.0)			
≥ 2 conditions	491 (76.1)		443 (74.8)		346 (73.0)			
≥ 3 conditions	360 (56.6)		320 (54.6)		247 (52.6)			
Missing ^c	25							
Mortality								
Living	664 (93.8)		590 (94.5)		468 (94.4)			
Deceased	43 (6.2)		35 (5.5)		28 (5.6)			(14.5) ^d
Characteristic, range	Mean (SE)		Mean (SE)		Mean (SE)		Mean	
Age in years	74.2 (0.3)		73.9 (0.4)		73.7 (0.4)		75.6	
PWI, 0–100	74.9 (0.6)		75.4 (0.6)		75.6 (0.6)			
SPANE, –24 to 24	12.7 (0.3)		12.9 (0.3)		13.2 (0.4)			
YPAS	49.2 (1.6)		50.1 (1.6)		51.2 (1.8)			
DBMA, 0–105	7.5 (0.4)		7.5 (0.4)		7.4 (0.4)			

^aCounts are unweighted; percentages were corrected for complex samples and weighted for the population distribution

^bData obtained from the Spanish Population and Housing Census 2011 (Instituto Nacional de Estadística 2013a) and the Spanish National Health Survey 2011–2012 (Instituto Nacional de Estadística 2013b)

^cIn order to make the columns comparable, missing values were not taken into account when calculating percentages

^dExpected 4, 7-year mortality proportion in our total sample calculated with national mortality data 2013 (Instituto Nacional de Estadística 2014)

DBMA Disease Burden Morbidity Assessment, MVR multivariate regression, PWI Personal Wellbeing Index, SE standard error, SPANE Scale of Positive and Negative Experience, YPAS Yale Physical Activity Survey

respectively. During the 5-year follow-up time, 6.2% of the participants in the total sample aged 65 years or more had died. This proportion was 5.5% among persons who answered the DBMA and 5.6% for the participants included in the MVR. When comparing our samples with national data, our samples showed higher educational levels, higher self-perceived health and a lower mortality rate than the general population.

The distribution of DBMA scores in the study sample is illustrated in Fig. 1, for the total sample, and by sex, age group and mortality. In our community-dwelling healthy population, there was an important floor effect (21.6% of the participants had a DBMA score < 2), with a median score of 5 and a range from 0 to 41. DBMA scores < 2 were more frequent among men, persons aged < 75 years and persons who did not die during follow-up time.

Predictive validity: mortality

The Cox regression model (Table 2) showed a significant association with age (hazard ratio (HR) = 1.091, 95% confidence interval (CI) = 1.026–1.161, $p = 0.006$) and sex (HR = 0.168, 95% CI = 0.056–0.500, $p = 0.002$). When adding disease burden to the model, the HR for age remained similar (HR = 1.085, 95% CI = 1.017–1.157, $p = 0.013$) and the HR for sex changed to 0.108 (95% CI = 0.024–0.483, $p = 0.004$). For disease burden, a higher adjusted risk of death was found for persons with a higher score on the DBMA scale than for persons with lower scores (HR = 1.073, 95% CI = 1.002–1.148, $p = 0.044$). Without correcting for complex samples or weighing, the HR for disease burden remained practically the same (HR = 1.076, CI = 1.016–1.140), but the p value decreased to 0.012.

As shown in Fig. 2, the Kaplan–Meier displayed higher survival rates for persons with lower DBMA scores than persons with higher scores. Both survival rates were above the expected survival rate for the general population.

Convergent validity: patient-centered outcomes and healthcare utilization

Among respondents with higher DBMA scores, there were significantly more women (77 vs. 53%, $p < 0.001$) and a higher mean age (75 vs. 73 years, $p = 0.04$) (Table 3). In this

Fig. 2 Kaplan–Meier probability of survival for high (≥ 10) and low (< 10) DBMA scores and expected mortality. *Expected mortality calculated with national mortality data 2013 for the Spanish general population (Instituto Nacional de Estadística 2014)

group, fewer persons reported being in good or very good health (21 vs. 68%), and these participants showed lower QoL (PWI: 69 vs. 78, $p < 0.001$), affect balance (SPANE: 9 vs. 14, $p < 0.001$) and physical activity (YPAS: 41 vs. 53, $p < 0.001$). More persons reported having any kind of disability (87 vs. 49%, $p < 0.001$), and there were 72% more primary care use (70 vs. 41%, $p < 0.001$) and 37% more secondary/tertiary care use (71 vs. 52%, $p < 0.001$).

Finally, in the bivariate glm, significant associations were found for all variables (Table 4). In the multivariable log-modified glm, female sex, disability and both healthcare use variables showed a significant and positive association with the DBMA. Self-perceived health, QoL, affect balance and physical activity were negatively associated with disease burden. No significant association was found for age when correcting for the other variables. The model explained 43% of the variance.

Discussion

This study analyzed the prospective association with 5-year mortality to assess the predictive validity of the DBMA, as well as the cross-sectional association of disease burden

Table 2 Cox regression ($n = 625$) for the risk of dying: bivariate model with age and sex and multivariate model with age, sex and disease burden measured by the DBMA

Variable	Bivariate model				Multivariate model			
	HR	SE	p value	95% CI	HR	SE	p value	95% CI
Age	1.091	0.034	0.006	1.026–1.161	1.085	0.035	0.013	1.017–1.157
Sex	0.168	0.093	0.002	0.056–0.500	0.108	0.082	0.004	0.024–0.483
DBMA					1.073	0.037	0.044	1.002–1.148

CI confidence interval, DBMA Disease Burden Morbidity Assessment, HR hazard ratio, SE standard error

Table 3 Differences between high and low disease burden scores for age and sex, patient-centered variables and utilization outcomes

Characteristic	<i>n</i>	DBMA < 10	DBMA ≥ 10	<i>p</i> value ^b
		(<i>n</i> = 474)	(<i>n</i> = 151)	
		<i>n</i> (%) ^a	<i>n</i> (%) ^a	
Sex	625	233 (52.6)	112 (76.9)	<0.001
Self-perceived health	615	322 (67.8)	31 (21.4)	<0.001
Functional status	596	220 (48.7)	127 (87.0)	<0.001
Primary care use	625	190 (40.8)	103 (70.2)	<0.001
Secondary/tertiary care use	625	224 (51.6)	109 (70.9)	<0.001
Characteristic, range		Mean (SE)	Mean (SE)	
Age	625	73.5 (0.4)	74.9 (0.6)	0.04
PWL, 0–100	540	77.7 (0.6)	69.1 (1.0)	<0.001
SPANE, –24 to 24	622	14.3 (0.3)	9.2 (0.7)	<0.001
YPAS	613	53.4 (2.0)	41.1 (2.4)	<0.001

^aCounts are unweighted; percentages were corrected for complex samples and weighted for the population distribution^b*p* values obtained by Chi-square tests (dichotomous variables) and Somers' *D* tests weighted for the population distribution (continuous variables)

DBMA Disease Burden Morbidity Assessment, PWI Personal Wellbeing Index, SE standard error, SPANE Scale of Positive and Negative Experience, YPAS Yale Physical Activity Survey

with specific patient-centered outcomes and healthcare use, for convergent validity. Disease burden, measured with the DBMA, was found to be statistically significantly associated with mortality, patient-centered outcomes (self-perceived health, functional status, QoL, affect balance and physical activity) and healthcare utilization (primary and secondary/tertiary care utilization). These results provide us with useful knowledge about the applicability of the DBMA, supporting its value in health surveillance and as a marker of risk of prevention efforts.

Predictive validity: mortality

We have found a positive association between the DBMA and mortality after 5-year follow-up time. For every point of increase in the DBMA total score, there was a 7% increased risk of death after 5 years, a similar risk to the one found for age, which was 8% for every year of increase in age. We repeated the Cox analysis without weighting the data, because of the few deaths that took place in our 'healthy' community-dwelling population. After this, the HR for disease burden remained practically the same, but the *p* value, which was on the border of significance, decreased to 0.012. This confirms that the higher *p* value of 0.044 was because of weighing in a sample with an already low mortality rate.

The Kaplan–Meier curve showed a higher mortality rate among the highest DBMA category. However, the survival rate still remained far above the expected in the general population, even in persons with high DBMA scores. The low mortality rate was probably due to the fact that the sample used in this study consisted of 'healthy' community-dwelling persons aged 65 years or more. This means that the least healthy population, which could be found in long-term care facilities and admitted to hospitals, was excluded. The comparison with national data in Table 1 confirms this assumption. Additionally, the persons that did answer the DBMA showed higher perceived health, lower multimorbidity rates and lower mortality in comparison with the whole sample aged 65 years and older, making the difference in health status with the national sample even more pronounced. The high health status resulted in a skewed distribution, with a large proportion of persons with a lower DBMA score, and lower mortality rate than the expected in the general population.

Convergent validity: patient-centered outcomes and healthcare utilization

In the bivariate and multivariable log-modified glm, significant associations between the DBMA and self-perceived health, functional status, QoL and affect balance were found. These results confirm the associations found in previous studies between the DBMA and patient-centered outcomes

Table 4 Association of age and sex, patient-centered variables and utilization outcomes with disease burden: bivariate and multivariable linear model

Variable, range		Bivariate analysis		Multivariable model	
		Coefficient	<i>p</i> value	Coefficient	<i>p</i> value
Intercept				3.848	< 0.001
Sex	Women	0.598	< 0.001	0.190	0.030
Age		0.017	0.019	0.001	0.824
Self-perceived health	Good/very good	− 0.928	< 0.001	− 0.422	< 0.001
Functional status	Disability	0.933	< 0.001	0.540	< 0.001
QoL (PWI), 0–100		− 0.040	< 0.001	− 0.023	< 0.001
SPANE, − 24 to 24		− 0.045	< 0.001	− 0.011	0.032
Physical activity (YPAS)		− 0.010	< 0.001	− 0.004	0.044
Primary care use		0.670	< 0.001	0.281	0.001
Secondary/tertiary care use		0.401	< 0.001	0.231	0.021

R^2 for model = 0.434, n = 496

PWI Personal Wellbeing Index, QoL quality of life, SPANE Scale of Positive and Negative Experience, YPAS Yale Physical Activity Survey

(Bayliss et al. 2005, 2009, 2012). The relation between the DBMA and the SPANE as a measure of affect balance had not been studied before. We found a negative association between affect balance and self-reported disease burden. This was expected, since studies have shown that the SPANE is negatively associated with depression (Cummins 2009) and depression positively associated with the DBMA (Bayliss et al. 2005).

A negative association of the DBMA with physical activity was found, indicating that persons with higher DBMA scores were less physically active. The relationship between the DBMA and physical activity could be bidirectional: On the one hand, physical inactivity is a well-known risk factor for chronic diseases and disability (Lee et al. 2012); on the other, physical limitations due to chronic diseases can lead to physical inactivity (Hudon et al. 2008). Interventions to promote physical activity should ideally start in younger adulthood, with an added advantage if started before the onset of chronic conditions, to prevent this vicious circle of physical inactivity and disability.

The multivariable glm showed no significant relation between the DBMA and age, which can be attributed to the fact that higher age is associated with lower physical functioning, less physical activity and lower perceived health (Pinquart 2001; Troiano et al. 2008; Windsor et al. 2013), and these variables were included in the model. Another possible explanation is that older people compare their health with that of persons of the same age. Henchoz et al. (2008) found that, although the number of conditions increased rapidly with age in octogenarians, their perceived health decreased in a much less steep way. The same mechanism could be the case for disease burden. Older persons might be more limited by their conditions, but since limitations are common in their age group, they do not experience them as seriously as younger people.

Female sex was positively associated with self-reported disease burden, indicating that women had higher scores on this scale than men, even after correcting for age. Previous studies have shown that multimorbidity, as well as disability, is more frequent among women (Barnett et al. 2012; Garin et al. 2014), which explains the positive association found in the current study.

The use of healthcare resources was added in this analysis as a system-centered outcome. However, these measures were self-reported, which implies that some level of subjectivity should be taken into account. In a recent Dutch study, community-dwelling older persons slightly overestimated healthcare utilization, and this was more frequent among people with multimorbidity and persons who reported to have a worse health status than a year before (van Dalen et al. 2014). However, the overall conclusion was that self-report of healthcare utilization in older community-dwelling persons was adequate and efficient.

We found significant positive associations between the DBMA and primary and secondary/tertiary care use, and these associations remained significant in the multivariate model. Bayliss et al. (2012) previously studied the relationship between the DBMA and utilization outcomes. They reported significant associations with outpatient utilization and inpatient admissions; the relation with emergency department admissions was not significant. They did the same analysis for the CCI, finding significant associations with the three utilization outcomes of a larger magnitude. Thus, it can be concluded that the DBMA is associated with utilization outcomes but it might be more appropriate to use the CCI when predicting the use of healthcare resources (Charlson et al. 2008; Bayliss et al. 2012).

There were limitations to this investigation. As stated before, we applied a multimorbidity assessment scale to a relatively healthy sample. This implies that our conclusions

cannot be extrapolated to less healthy samples, in which the application of the DBMA would be of special interest. In addition, there was a large proportion of missing values, caused by persons who did not participate in the CAPI at all as well as by persons who did not answer the DBMA or other questions of the CAPI questionnaire. The CAPI was a quite large questionnaire which might have influenced the willingness to (completely) fill it out, especially for persons with a low health status. An earlier published study about the ELES-PS already described that persons who did not respond the CAPI were of higher age and reported lower self-perceived health (Rodríguez Laso et al. 2013).

Another limitation was that we obtained mortality data from the Spanish National Death Index. Despite the fact that we repeated the search manually, it is possible that we slightly underestimated the mortality rate because of matching errors between our database and the Ministry of Health's. And finally, we have not been able to compare the associations we found for the DBMA with those of another multimorbidity assessment instrument, such as the CCI, which was not included in our study. The association between patient-centered outcomes and utilization outcomes was compared before (Bayliss et al. 2005, 2012), showing that the DBMA was more related to the former and less to the latter than the CCI, but the performance predicting mortality has never been compared. Further research should include this comparison with other multimorbidity tools, which would facilitate the selection of the most appropriate instrument, dependent on the outcomes of interest.

In summary, our findings suggest that the DBMA, as a measure of disease burden, shows satisfactory predictive validity with mortality and adequate convergent validity with patient-centered outcomes and healthcare utilization outcomes in community-dwelling older adults. Since our sample showed a relatively high health status, these results should be confirmed in a hospital-based sample. The DBMA is a self-reported questionnaire that repeats the same question for different conditions, which makes it easy to understand and to be filled out in a short amount of time. In our aging society, with increasing numbers of older people with multimorbidity, it might be applied to better understand and improve care for older persons with multiple chronic conditions.

Funding The authors disclose receipt of the following financial support: ELES-PS (ref: CSO2011-30210-C02-01), funded by the I+D+I National Plan, Spanish Ministry of Education and Science; ENCAGE-CM (ref: S2015/HUM-3367), funded by the I+D Activity Program of Madrid Community research groups on social sciences and humanities and co-funded by the European Social Fund; and ENVACES (ref: CSO2015-64115-R), funded by the Spanish Ministry of Economy, Industry and Competitiveness and co-funded by the European Social Fund. In addition, this work arises from the Joint Action on Chronic Diseases and Promoting Healthy Ageing across the Life Cycle (JA-CHRODIS), which has received funding from the European Union, in

the framework of the Health Programme (2008–2013). Sole responsibility lies with the author, and the Consumers, Health, Agriculture and Food Executive Agency is not responsible for any use that may be made of the information contained therein.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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