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The prediction of mortality by quality of life assessed with the WHOQOL-BREF: a longitudinal analysis at the domain and item levels using a seven-year follow-up period

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Abstract

Purpose To determine the predictive value of quality of life for mortality at the domain and item levels.

Methods This longitudinal study was carried out in a sample of 479 Dutch people aged 75 years or older living independently, using a follow-up of 7 years. Participants completed a self-report questionnaire. Quality of life was assessed with the WHOQOL-BREF, including four domains: physical health, psychological, social relationships, and environment. The municipality of Roosendaal (a town in the Netherlands) indicated the dates of death of the individuals.

Results Based on mean, all quality of life domains predicted mortality adjusted for gender, age, marital status, education, and income. The hazard ratios ranged from 0.811 (psychological) to 0.933 (social relationships). The areas under the curve (AUCs) of the four domains were 0.730 (physical health), 0.723 (psychological), 0.693 (social relationships), and 0.700 (environment). In all quality of life domains, at least one item predicted mortality (adjusted).

Conclusion Our study showed that all four quality of life domains belonging to the WHOQOL-BREF predict mortality in a sample of Dutch community-dwelling older people using a follow-up period of 7 years. Two AUCs were above threshold (psychological, physical health). The findings offer health care and welfare professionals evidence for conducting interventions to reduce the risk of premature death.

Keywords Older people · Quality of life · Mortality · WHOQOL-BREF

Introduction

In Western societies, the quality of life of community-dwelling older people is an important topic, especially now that aging in place has become popular among government policies and older people themselves [1, 2]. In the Netherlands, where this study was carried out, it has been forecast that by 2050, 33.2% of the population will be 60 years or older [3]. Dutch politics also encourages aging in place. The goals of aging in place are twofold. First, from the perspective of older people, most prefer to grow old in their own homes and environment. Satisfaction with housing and the environment (e.g., residents, nuisance) is important for older people, as it is associated with quality of life [4]. Moreover, for Dutch older people, being active, the possibility to support other people, feeling good, being in good health, and having social contacts are essential for good quality of life [5]. For many older people, staying at home is related to being surrounded by family and friends who can provide informal care when physical limitations make it difficult to live independently. Second, from the perspective of policymakers, the provision of care in the community is much cheaper than institutionalization; in the Netherlands, an admission to a nursing home is only possible for people who can really no longer stay at home, for example, because there is no informal care or because people need too much professional support like people with advanced dementia. So aging in place can be

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considered as a cost effective solution for long-term care for older people.

Quality of life of older people appears to be benefiting from aging to place because the autonomy and social contacts are maintained [5, 6]. Quality of life is defined in different ways. A frequently cited definition of quality of life is developed by the World Health Organization: "individuals' perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns" [7]. Quality of life in older people is influenced by sociodemographic factors (e.g., gender, age, marital status, education, income) [8–10]; these effects are not unequivocal because they are related to the measurement instrument used [11]. Well-known instruments for assessing quality of life are the World Health Organization Quality of Life Questionnaire-BREF (WHOQOL-BREF) [12], the Short Form Health Survey (SF-12) [13], and the EuroQoL 5D (EQ-5D) [14].

Studies have showed frailty and disability, commonly present in community-dwelling older people, are associated with a lower quality of life [15, 16]. In addition, it is known that quality of life predicts institutionalization and premature death among community-dwelling older people, even after controlling for frailty and disability [17]. Concerning premature death, several other studies have been carried out to establish the predictive value of quality of life for mortality [18–21]. In a Chinese population of 1,739 individuals, with a mean age of 57.7 years, lower quality of life was associated with an increased risk of all-cause mortality using a follow-up of 10 years [20]; 49.6% and 24.8% of the sample had an age of 60–69 years and ≥ 70 years, respectively. In 4424 community-dwelling individuals residing in Taiwan, quality of life, assessed with the 36-Item Short Form Health Survey (SF-36) [22], predicted 3-year mortality; both the physical component summary (PCS) and the mental component summary (MCS) were associated with higher mortality [21]. Another study conducted among 105,000 American people aged 65 years or older reported that four measures of quality of life (general self-reported health, physically unhealthy days, mentally unhealthy days, and days with activity limitations) predicted mortality at 90 days and 2.5 years [18]. In Germany, it was observed in a sample of 4261 people aged 20–79 years that quality of life, assessed with the 12-item Short Form Health Survey (SF-12), predicted mortality better than a combination of 10 biomarkers using a follow-up with an average of 9.7 years; low PCS-12 scores were significantly associated with increased risk of mortality [19].

The association between quality of life and mortality should be examined in different kind of populations. To the best of our knowledge, no study has been carried out in the Netherlands to examine this association among community-dwelling older people. Therefore, the aim of the present study was to determine the predictive value of quality of life for mortality in a sample of Dutch people aged 75 years or older living independently. Moreover, we determine the prediction of mortality by quality of life on two levels: using quality of life domains and checking the predictive value of the individual items within these quality of life domains.

Methods

Study population and data collection

For this study, we used a randomly drawn sample consisting of 479 people aged 75 years or older living in Roosendaal, a municipality with 78,000 inhabitants in the Netherlands. In June 2008, this sample completed a questionnaire including validated measurement instruments concerning frailty, disability, and quality of life, which they had received by post. Many participants completed the questionnaire themselves; 15.4% of the participants received help from a close relative. The questionnaire was returned by post to the principal investigator. The sample, which represents a response rate of 42%, was used in studies conducted in 2010 and 2012; for more details, we refer to those studies [23, 24]. More recently, the same sample was used for the prediction of frailty and disability [25, 26].

Measures

Quality of life

We assessed quality of life with the WHOQOL-BREF [12]. The WHOQOL-BREF is a self-report questionnaire containing 26 items. One item refers to overall quality of life, and another item refers to general health. The remaining 24 items are distributed among four quality of life domains: physical health (seven), psychological (six), social relationships (three), and environment (eight). Each item was rated on a five-point scale; higher scores indicated greater quality of life. The quality of life domain scores were calculated as means of the underlying items in the domain where at most one missing value was allowed and then multiplied by 4, resulting in a range from 4 to 20 [12]. The WHOQOL-BREF has shown good psychometric properties for assessing quality of life among community-dwelling older people [27, 28].

Mortality

In August 2015, the municipality of Roosendaal indicated the dates of death of the individuals who completed the questionnaire in June 2008; this implied a follow-up of around 7 years.

Sociodemographic characteristics

We collected the following sociodemographic characteristics from the participants: gender, age, marital status, education, and net monthly income. As mentioned in the introduction, these characteristics are associated with quality of life [8–11].

Statistical analyses

For this study, we made use of the TRIPOD Checklist Prediction Model Development [29]. Descriptive statistics were used to analyze the sociodemographic characteristics of the participants, the scores on the quality of life domains, and items of the WHOQOL-BREF. Categorical variables were presented as numbers with percentages and continuous variables as means with standard deviations. The date of mortality of the participants was used as a time-to-event outcome. The time 0 days corresponded with the time of death of the first participant, and the time 2613 days concerned participants who were still alive.

Both bivariate and multivariable analyses of survival were carried out. Therefore, Kaplan–Meier analyses and Cox regression analyses were used to calculate hazard ratios (HRs) with 95% confidence intervals (95%-CI). In these analyses, the quality of life domain and item scores served as predictors. Only items with a bivariate p-value < 0.20 were included in the multivariable analyses [30].

Since no cut-off points for the four quality of life domain subscale scores exist, we decided to establish data-driven cut-off points by using a grid of cut-off values for each of these scores. For each cut-off value of a domain score, both sensitivity (se) and specificity (sp) were calculated for the prediction of mortality with Cox regression. Then the cut-off value that minimized $\sqrt{(1-se)^2+(1-sp)^2}$ was defined as the best [31]. The log-rank test was used to compare the Kaplan–Meier survival curves with respect to subgroups.

In subsequent analyses, we adjusted for sociodemographic characteristics of the participants (gender, age, marital status, education, income). The predictive performance of the models was measured using the area under the receiver operating characteristics (ROC) curve (AUC). An AUC > 0.700 was regarded as an indication for good predictive performance of the model [30]. A p-value < 0.05 was considered as significant. For all analyses, we used R version 3.4.4.

Results

Characteristics of the participants

Table 1 presents the sociodemographic characteristics of the 479 participants at baseline (June 2008). The mean age for the total sample was 80.3 ± 3.8 years; the majority was female ($n = 272$; 56.8%) and married or cohabiting ($n = 238$; 49.8%). For 46.5% of the participants, secondary education was the highest level achieved, and 43.1% had a net monthly income lower than €1201,-. Within the follow-up period of 7 years, 162 individuals died.

Table 1 also presents the scores on the four quality of life domains. The sample scored highest on the quality of life domain social relationships (mean 15.8; standard deviation 2.9) and lowest on the quality of life domain physical health (mean 14.7; standard deviation 3.1). Of the participants, 82.7% rated their overall quality of life as good or very good. In addition, 71.2% of the sample was satisfied or very satisfied with their general health. Items that scored lowest were work capacity (22.4% very dissatisfied or dissatisfied), participation in and opportunities for recreation/leisure activities (18.6% not at all or a little), and mobility (18.0% very poor or poor). Regarding sexual activity, 7.1% of the participants were very dissatisfied. On the other hand, 46.7% of them were very satisfied with personal relationships. For more details, we refer to Fig. 1.

Prediction of mortality by quality of life domain scores

Table 2 shows the HRs for the four quality of life domains of the WHOQOL-BREF together with 95%-CIs. All domains predicted mortality, unadjusted and adjusted for gender, age, marital status, education, and income, with p-values < 0.001 for physical health and psychological. The unadjusted AUCs ranged from 0.564 (social relationships) to 0.666 (physical health). In addition, the adjusted AUCs ranged from 0.693 (social relationships) to 0.730 (physical health).

Prediction of mortality by quality of life domains based on cut-off points

Table 2 also shows the unadjusted and adjusted HRs using the cut-off values determined as described in the statistical analyses subsection. For physical health, psychological, social relationships, and environment, the cut-off points were 14.0, 14.7, 14.7, and 15.5, respectively. Scores higher than these cut-off points indicated good quality of life. The AUCs demonstrated again that physical health, psychological, and environment predicted mortality, but were somewhat lower compared with the scores based on mean due to the categorization, except for the quality of life domain physical health (adjusted 0.733 versus 0.730).

Figure 2 presents the survival plots distinguishing participants with poor and good quality of life with regard to the quality of life domains of the WHOQOL-BREF. The p-values of the log-rank test for the comparison of the Kaplan–Meier survival curves are shown in each plot. For

Table 1 Participant characteristics

Characteristic	Category	*n*	%
Sex	Man	207	43.2
	Woman	272	56.8
Marital status	Married or cohabiting	238	49.8
	Other	240	50.2
Education	No or primary	181	38.1
	Secondary	221	46.5
	Higher	73	15.4
Net monthly income	€600 or less	12	2.7
	€601–€900	71	16.2
	€901–€1200	106	24.2
	€1201–€1500	57	13.0
	€1501–€1800	67	15.3
	€1801–€2100	48	11.0
	€2101 or more	77	17.6
		Mean	SD
Continuous variables	Age	80.3	3.8
	Physical health	14.7	3.1
	Psychological	15.4	2.0
	Social relationships	15.8	2.9
	Environment	15.7	2.2

the plots in relation to physical health, psychological, and environment, the survival curves between the two subgroups differed significantly (all p-values < 0.05).

Prediction of mortality by the individual items per quality of life domain

Bivariate analyses with Cox regression were conducted to examine which of the 26 items had a p-value < 0.20 with regard to mortality; only those that met this requirement were included in the multivariable analyses. These analyses were focused on the prediction of mortality by an individual item within a domain. It appeared that the items personal relationships (belonging to the social relationships domain) and physical environment (pollution/noise/traffic/climate) (belonging to the environment domain) had a p-value ≥ 0.20, so we excluded these items (the results of the bivariate analyses are not presented).

Table 3 shows the results of the multivariable analyses per domain. Regarding the quality of life domain physical health, the unadjusted and adjusted analyses demonstrated that the items dependence on medicinal substances and medical aids and activities of daily living significantly predicted mortality. The item mobility only predicted mortality in the unadjusted analysis. Of the six items belonging to the psychological domain, only self-esteem predicted mortality, unadjusted and adjusted. The social domain consisted of only two items: sexual activity and social support. Of these, the first predicted mortality in both analyses. Finally, participation in and opportunities for recreation/leisure activities of the quality of life domain environment predicted mortality (unadjusted). The individual items overall quality of life and general health predicted mortality in the unadjusted and the adjusted analyses. However, it should be noted that in the unadjusted analyses, only bivariate analyses were conducted. For further details, we refer to Table 3.

The unadjusted and adjusted AUCs of the 26 individual quality of life items varied from 0.508 to 0.660 with mean 0.588 and from 0.682 to 0.737 with mean 0.701, respectively. The unadjusted AUCs for the physical health, psychological, social relationships, and environment domains, based on multivariable analyses, were 0.698, 0.675, 0.599, and 0.626, respectively; the adjusted AUCs were 0.746, 0.743, 0.708, and 0.698 respectively.

Discussion

In this study, we examined the predictive value of the WHOQOL-BREF for mortality in a sample of 479 Dutch community-dwelling people ≥ 75 years using a follow-up of 7 years. In concrete terms, this meant that we determined the prediction of mortality by four quality of life domains (physical

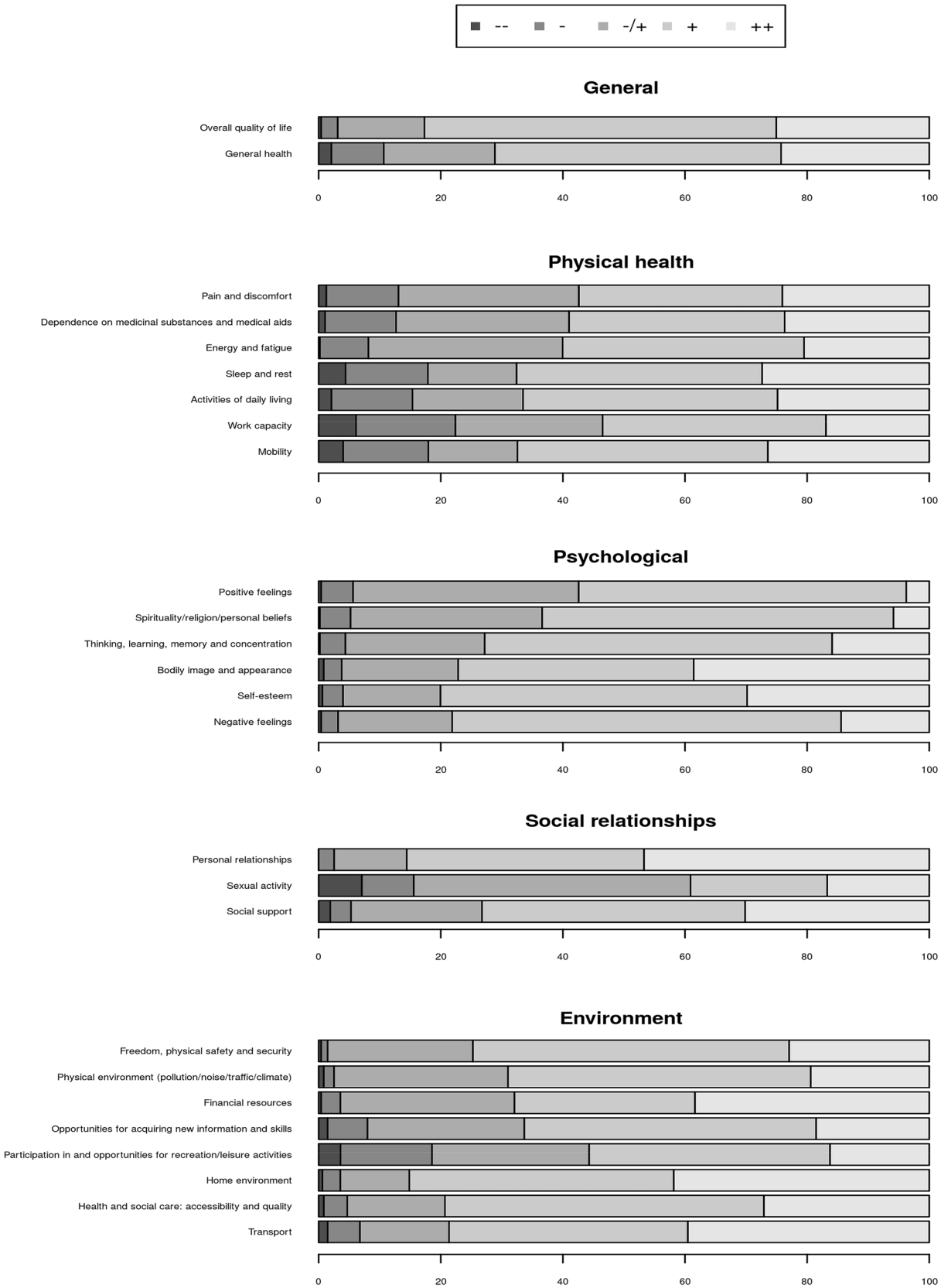

Fig. 1 Scores on quality of life items

Table 2 HRs, CIs, *p*-values and AUCs for mortality

	Unadjusted					Adjusted				
	HR	95%-CI	*p*-value	AUC	95%-CI	HR	95%-CI	*p*-value	AUC	95%-CI
Based on mean										
Physical health	0.847	[0.807, 0.889]	< 0.001	0.666	[0.613, 0.719]	0.859	[0.813, 0.907]	< 0.001	0.730	[0.679, 0.782]
Psychological	0.818	[0.761, 0.879]	< 0.001	0.629	[0.576, 0.681]	0.811	[0.746, 0.880]	< 0.001	0.723	[0.672, 0.774]
Social relationships	0.932	[0.883, 0.983]	0.010	0.564	[0.508, 0.620]	0.933	[0.880, 0.990]	0.021	0.693	[0.640, 0.747]
Environment	0.873	[0.817, 0.933]	< 0.001	0.599	[0.546, 0.653]	0.883	[0.817, 0.955]	0.002	0.700	[0.647, 0.753]
Based on cut-off										
Physical health	0.374	[0.274, 0.511]	< 0.001	0.646	[0.600, 0.691]	0.390	[0.275, 0.554]	< 0.001	0.733	[0.682, 0.783]
Psychological	0.585	[0.430, 0.797]	0.001	0.578	[0.532, 0.625]	0.585	[0.412, 0.831]	0.003	0.698	[0.645, 0.751]
Social relationships	0.760	[0.556, 1.039]	0.085	0.546	[0.498, 0.593]	0.750	[0.530, 1.060]	0.103	0.686	[0.632, 0.740]
Environment	0.625	[0.457, 0.854]	0.003	0.572	[0.525, 0.620]	0.714	[0.501, 1.016]	0.061	0.695	[0.642, 0.747]

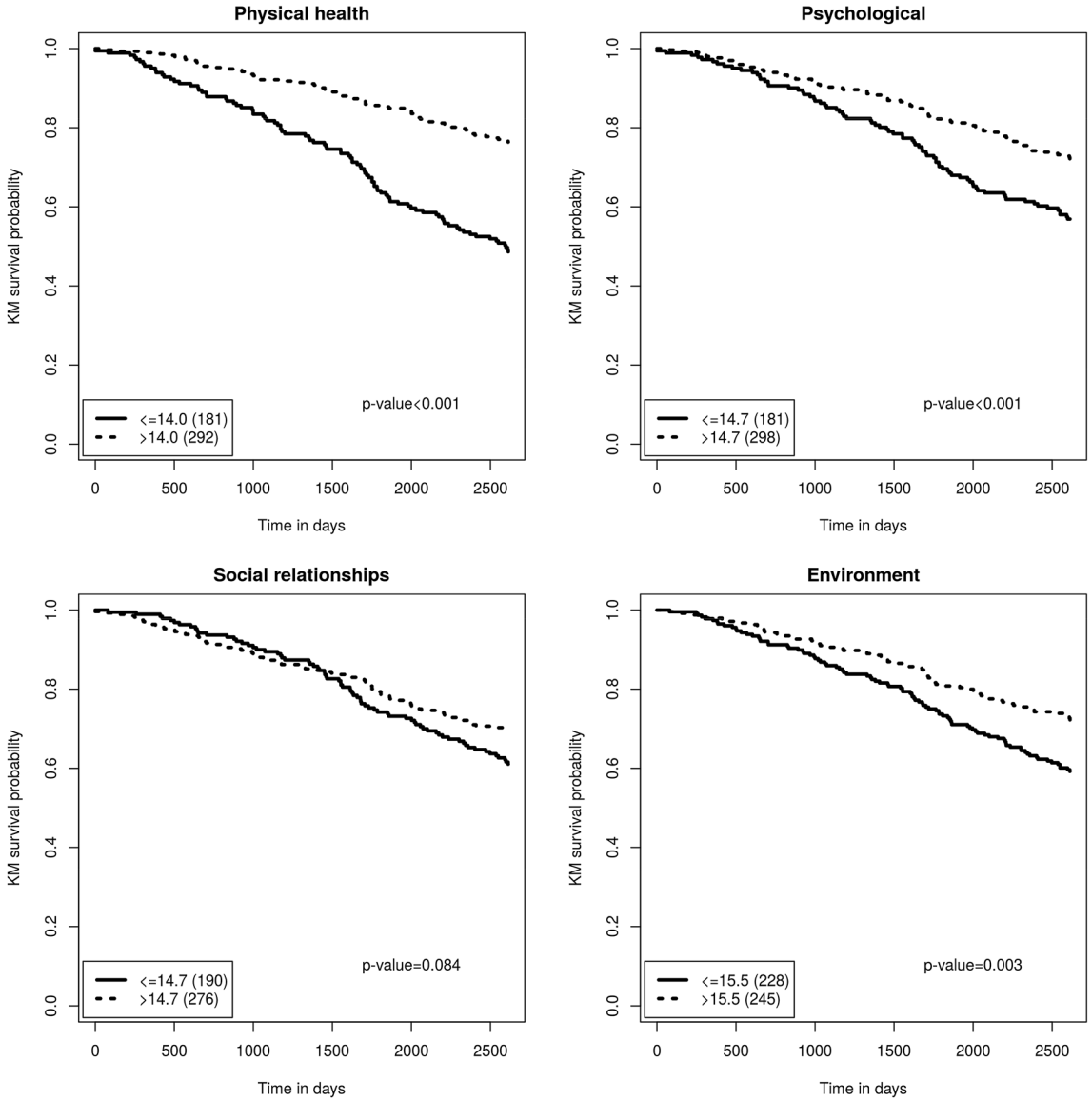

Fig. 2 Survival plots distinguishing good quality of life from poor quality of life

Table 3 HRs, CIs and *p*-values for mortality per quality of life item

Items	Unadjusted			Adjusted		
	HR	95%-CI	*p*-value	HR	95%-CI	*p*-value
Overall quality of life	0.615	[0.509, 0.744]	< 0.001	0.613	[0.495, 0.760]	< 0.001
General health	0.754	[0.651, 0.874]	< 0.001	0.815	[0.695, 0.955]	0.012
Physical health						
Pain and discomfort	1.121	[0.905, 1.389]	0.296	1.133	[0.902, 1.421]	0.283
Dependence on medicinal substances and medical aids	0.765	[0.619, 0.944]	0.012	0.766	[0.606, 0.967]	0.025
Energy and fatigue	0.915	[0.717, 1.169]	0.478	0.861	[0.657, 1.128]	0.278
Sleep and rest	1.159	[0.991, 1.356]	0.064	1.145	[0.968, 1.355]	0.113
Activities of daily living	0.776	[0.608, 0.991]	0.042	0.753	[0.581, 0.976]	0.032
Work capacity	0.953	[0.749, 1.213]	0.698	0.938	[0.725, 1.213]	0.624
Mobility	0.801	[0.671, 0.957]	0.014	0.937	[0.762, 1.151]	0.534
Psychological						
Positive feelings	0.737	[0.552, 0.983]	0.038	0.756	[0.540, 1.059]	0.104
Spirituality/religion/personal beliefs	1.065	[0.818, 1.387]	0.641	1.003	[0.740, 1.359]	0.985
Thinking, learning, memory and concentration	0.821	[0.652, 1.036]	0.096	0.885	[0.680, 1.153]	0.366
Bodily image and appearance	1.224	[0.999, 1.500]	0.051	1.126	[0.892, 1.422]	0.318
Self-esteem	0.658	[0.520, 0.833]	0.001	0.707	[0.548, 0.913]	0.008
Negative feelings	0.818	[0.644, 1.040]	0.101	0.795	[0.610, 1.036]	0.089
Social relationships						
Sexual activity	0.790	[0.658, 0.949]	0.012	0.780	[0.641, 0.950]	0.013
Social support	0.897	[0.727, 1.105]	0.306	0.916	[0.730, 1.149]	0.447

Table 3 (continued)

Items	Unadjusted			Adjusted		
	HR	95%-CI	*p*-value	HR	95%-CI	*p*-value
Environment						
Freedom, physical safety and security	0.903	[0.708, 1.151]	0.410	0.886	[0.685, 1.147]	0.360
Financial resources	1.038	[0.850, 1.266]	0.716	1.098	[0.870, 1.386]	0.430
Opportunities for acquiring new information and skills	0.977	[0.783, 1.220]	0.839	0.997	[0.792, 1.255]	0.981
Participation in and opportunities for recreation/leisure activities	0.791	[0.668, 0.936]	0.006	0.856	[0.708, 1.034]	0.107
Home environment	0.852	[0.666, 1.090]	0.202	0.826	[0.634, 1.077]	0.159
Health and social care: accessibility and quality	1.006	[0.808, 1.253]	0.955	0.964	[0.759, 1.224]	0.762
Transport	0.978	[0.813, 1.176]	0.812	0.947	[0.777, 1.154]	0.589

health psychological, social relationships, and environment) and related items.

The present study showed that three out of four quality of life domains predicted mortality—physical health, psychological, and environment—unadjusted and adjusted for gender, age, marital status, education, and income. Additional analyses using cut-off points for distinguishing people with poor and good quality of life supported these findings. All AUCs (unadjusted) were < 0.700, ranging from 0.546 (social relationships) to 0.666 (physical health). Three AUCs (adjusted) were > 0.700; this applied to physical health (based on mean, based on cut-off) and psychological (based on mean). In a sample of 689 Taiwanese male residents of veteran homes aged 65 years or older, the domains of the WHOQOL-BREF did not predict mortality during a 2-year follow-up, after adjusting for many other predictors including age, hospitalization, and life satisfaction [32]. Also in Taiwan, a study among 423 patients with chronic kidney disease with an average age of 57.0 years showed in adjusted analyses that the physical health and psychological domains significantly predicted mortality with a median follow-up period of 410 days; the HRs were 1.179 (95%-CI 1.033–1.346) and 1.167 (95%-CI 1.016–1.339), respectively [33]. The Lothian Birth Cohort 1921 Study demonstrated that of the WHOQOL-BREF domains, only physical health predicted mortality in a sample of 448 healthy older people with a mean age of 79.0 years after adjustment for age and gender, using a 9-year follow-up (HR 0.90, 95%-CI 0.86–0.95) [34]. Our findings are partly supported by the aforementioned studies. It should be noted that comparison of results is limited; despite the fact that the same measurement instrument has been used in all studies (WHOQOL-BREF), differences were present concerning country, sample (e.g., age, specific groups), and variables for adjustment. These differences may explain why the findings are inconsistent. Of aforementioned studies our study is most comparable with the Lothian Birth Cohort 1921 Study: age category (mean age around 80 years, gender (both men and women), country (European). However, in this last study, the participants were healthy; in our sample, the prevalence of frailty and disability was 47.1% and 34.8%, respectively [24]. Then you also expect an association between multiple quality of life domains and mortality.

Multivariable analyses examining the prediction of mortality by each individual item per quality of life domain showed that in each domain at least one item was significantly associated, unadjusted and/or adjusted for sociodemographic characteristics of the participants. Physical health items dependence on medicinal substances and medical aids, activities of daily living (ADL), and mobility predicted mortality, the latter only after adjustment. The first item refers to having a chronic disease or multiple chronic diseases simultaneously (multimorbidity). Multimorbidity

is related to greater age. Several previous studies among community-dwelling older people have showed that people with multimorbidity have an increased risk of mortality, including a study among 1751 Canadian people aged 65 years or older [35] and a sample of 1099 Swedish individuals aged 78 years or older [36], with a follow-up period of 5 and 11 years, respectively. Both disability in ADL and poor mobility are well-known predictors of mortality. With regard to disability in ADL, in a sample of 1333 Brazilian people ≥ 60 years, a mortality rate of 46.1 per 1000 person-years at risk was observed [37]. Poor mobility, reflected by slow walking speed, predicted mortality in a large sample of Chinese, Indian, and Latin American people [38]. In addition, this finding was confirmed by a systematic review conducted by the International Academy on Nutrition and Aging (IANA) Task Force [39].

In the psychological quality of life domain of the WHOQOL-BREF, the items positive feelings and self-esteem significantly predicted mortality, but after controlling for the five sociodemographic characteristics, only self-esteem predicted mortality. Self-esteem can be defined as the feeling, appreciation, and consideration that people have for themselves—namely, how much they like themselves, how they see, and what they think about themselves [40]. A study among 2682 Finnish males showed no association between self-esteem and mortality, after adjustment for other psychosocial characteristics like depression and hopelessness [41]. This is supported by the terror management theory that states that great self-esteem buffers against death-related thought and anxiety [42]. Based on our findings and previous findings, it is recommended to conduct studies focused on the association of self-esteem and mortality, bearing in mind that in our study positive feeling also predicted mortality (unadjusted).

The quality of life domain social relationships contained only two items in the multivariable analyses: sexual activity and social support. In the unadjusted and adjusted analyses, sexual activity predicted mortality significantly. A study examining the longitudinal association between progressive temporal change in sexual functioning in community-dwelling older men (≥ 70 years) found that sexual activity predicted mortality using a follow-up of 7 years (odds ratio [OR] 2.37, 95%-CI 1.33–4.20) [43]. However, this was only demonstrated in univariable analyses; after adjustment for age, the significant association disappeared. In women, a lower frequency of sexual activities was associated with a decline in self-rated health (OR 1.64, 95%-CI 1.07–2.51). Health care professionals, including general practitioners and community nurses, should be mindful that older people with dissatisfaction about their sexual activity have increased risks for adverse outcomes [44]. This is still too much of a taboo subject. People of an advanced age also have sexual desires and needs; health care professionals should pay attention to this and it should be possible to discuss this, which requires good conversation skills. Training courses should focus on this subject.

In the quality of life domain environment, only participation in and opportunities for recreation/leisure activities turned out to predict mortality (unadjusted). The Leisure World Cohort Study including 8371 females and 4828 males also showed that participation in leisure-time activities reduced mortality [45]; spending a half-hour per day provided significantly lower mortality risks of 15–35% compared to spending no time in leisure activities. Results of another longitudinal study with a follow-up of 12 years suggest gender differences with regard to the association between leisure activity and mortality [46]; in women, social activities had the strongest effects on survival, while in men, solitary activities seem to be the most beneficial. In general, evidence derived from systematic reviews and meta-analyses demonstrated that leisure activities referring to physical activities demonstrate lower risks of mortality [47, 48].

Finally, the overall quality of life and general health items demonstrated predictive value in both the unadjusted and adjusted analyses. It should be mentioned there was no controlling for other quality of life items, because these two items do not belong to a quality of life domain. However, other studies only partially support our findings [32, 34]. In the previously quoted Lothian Birth Cohort 1921 Study, the general health item was the only item of the WHOQOL-BREF that predicted mortality after a 9-year follow-up, after controlling for age and sex (HR = 0.75, 95%-CI 0.64–0.89), so the other item (overall quality of life) had no predictive value [34]. In another study, neither item predicted mortality after controlling for many variables, including medical status and physical performance [32]. Because both items are not concrete and therefore do not give direction for interventions by health care and welfare professionals, we recommend to assess quality of life with the subscales of the WHOQOL-BREF (physical health, psychological, social relationships, and environment).

Some limitations of the present study should be mentioned. First, generalizability of the findings should be called into question, because the sample consisted only of people residing in one municipality in the Netherlands (Roosendaal). In addition, the sample represented a response rate of 42%, which is not high. Possibly, the most frail people decided not to participate in the study. A systematic review and meta-analysis has shown that more frailty is associated with lower quality of life in older people [49]. Moreover, frailty is a predictor of mortality [50]. A larger sample size, including more frail older people, possibly provided a better predictive value of quality of life for mortality. Second, we determined the prediction of mortality by the individual items of the WHOQOL-BREF. These all relate to just one question. We recommend to examine the predictive value of

the concepts in the WHOQOL-BREF for mortality also by validated measures. For example, Rosenberg's Self-esteem Scale (RSES), a questionnaire consisting of 10 items, could be used to assess the concept of self-esteem [51]. Third, the potential effect of the limited sample size ($n = 479$) on the findings. Fourth, after eliminating one item (personal relationships) belonging to quality of life domain social relationships, only two items were included in the multivariable analyses. This may have affected the performance of this domain. Finally, the data with regard to quality of life and mortality have been only collected from people living in the municipality of Roosendaal. So it is possible that people have moved to another municipality in the meantime and died there.

In conclusion, our study showed that all four quality of life domains belonging to the WHOQOL-BREF (physical health, psychological, social relationships, and environment) predict mortality in a sample of Dutch community-dwelling older people using a follow-up period of 7 years. It should be noted that all unadjusted AUCs were below threshold, indicating some weak predictive performance. However, two AUCs were above threshold after adjustment (psychological, physical health). Analyses of the predictive value of the individual items of the WHOQOL-BREF showed that dependence on medicinal substances and medical aids, ADL, self-esteem, and sexual activity significantly predicted mortality after controlling for the other items in the same domain, both unadjusted and adjusted for sociodemographic characteristics. The findings offer health care and welfare professionals evidence for conducting interventions to reduce the risk of premature death.

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Author contributions RG involved in study concept and design, acquisition of subjects and data, and preparation of the manuscript (drafting, final approval). TP participated in study concept and design, analysis and interpretation of the data, and preparation of the manuscript (drafting, final approval). Both authors agree to be accountable for all aspects of the work.

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Availability of data All data were pseudonymized and stored in a central and secure server at Inholland University of Applied Sciences. Furthermore, we have complied with the law with regard to personal data privacy information (Dutch Data Protection Authority) [52].

Compliance with ethical standards

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

Ethical approval For the present study, medical ethics approval was not necessary because particular treatments or interventions were not offered or withheld from respondents. Moreover, the integrity of respondents was not encroached upon as a consequence of participating in this study, which is the main criterion in medical–ethical procedures in the Netherlands [53]. This research was conducted according to the guidelines for good clinical practice [54]. The researchers did not make the questionnaire long so the burden on participants would be limited; the average time for completing the questionnaire was 20 min. In addition, the questionnaire contained measures that have already been used in many previous studies among older people, including the WHOQOL-BREF. Both researchers have a PhD; during the PhD trajectory, much attention was paid to ethical aspects of good research.

Informed consent Informed consent related to detailing the study (e.g., information about the purpose of the study) and maintaining confidentiality was observed.

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