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Original Article

Health Related Quality of Life in Adults with 13 Chronic Diseases before Age 65 and after Age 65 Using Fuzzy Rough Analysis of SF-36 Domains

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ABSTRACT: An important factor in quality-of-life research is age. The deterioration of health-related quality of life (HR - QoL) in a group of patients is repeatedly emphasized. It is necessary to analyze which diseases (groups of diseases), in which spheres and how strongly they reduce HR - QoL. The purpose of this study was to analyze the level of HR-QoL experienced in each sphere and evaluate their influence in a given disease before and at age 65 and older. The cross-sectional study was carried out in Poland on a group of 7620 patients in 13 different disease groups. HR-QoL was assessed using the SF-36. Inclusion criteria were: age≥18 years, chronic disease ≥2 years, no other comorbidities (double verification of the criterion: treatment at a specialist clinic for a given chronic disease and questions excluding other comorbidities), and consent to participate in the study. Analysis was performed in two age groups (<65 and ≥ 65 years old) using fuzzy set method, a hierarchical cluster analysis and Student's t test. Correlation analysis in the group of patients before 65 years of age indicated a strong correlation between the variables: LD-RE (0.88), DSD-C-RP (0.75). In the group aged 65 and older indicated strong correlations between: NS-HCh (0.78) and NS-BP (0.70). CD, CVD and NS (with the exception of the RE sphere) were among the group of diseases that most severely lowered HR - QoL in the individual spheres of the SF-36 in the group of patients under 65 years of age. Among patients 65 and older, the group of diseases lowering HR - QoL was much more numerous: CD, CVD, NS, DM, DS, DSD-C, DSD-Th and depended on the individual spheres of quality of life assessed in the SF-36. DSD-C, DM, DS lowered HR - QoL of the older group of patients in the spheres: PF, RP, BP, GH, VT, SF, RE.

Keywords: health related – quality of life, chronic diseases, age, SF-36, fuzzy-rough analysis

INTRODUCTION

Health-related quality of life (HR – QoL) is an important aspect of the daily functioning of a person diagnosed with a chronic disease. Age is an important factor in the perception of HR – QoL. Many studies highlight the significant deterioration of quality of life, both physically and mentally, increasing with the years of life [1–5]. The phenomenon of an ageing population as a result of advances in medicine, technology, better healthcare, improved nutrition and, therefore, an increase in life expectancy, while at the same time reducing the proportion of the population that is productive, young, cannot be ignored either [6].

A whole spectrum of different factors: individual, social, environmental determine the perceived level of HR-QoL. Emotional intelligence is also an important factor. This is another key aspect that facilitates the process of adaptive emotion regulation [7]. Studies show that high emotional intelligence correlates with lower

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levels of anxiety and depression [8]. Thus, proper emotional regulation is the key to well-being and good HR-QoL of the patient, both mentally and physically.

Earlier studies by the authors included an analysis of data regarding the ranking of diseases that are most strongly correlated with reduced HR-QoL [9] and an analysis of quality of life across different age groups [10]. After data verification, it was decided to perform an additional subanalysis by dividing into two age groups: under 65 years (Group 1) and 65 years and older (Group 2). To verify which domains are most strongly correlated with a given disease, new methodologies were applied a hybrid approach to data mining was used, based on fuzzy and rough sets.

Fuzzy [11] and rough [12] sets theories provide a methodology for thorough data analysis and knowledge extraction. Recently, a new method of attribute selection based on fuzzy relational equations and the degree of attribute-decision relationship was introduced [13].

In this paper basing on fuzzy relational equations and rough set theory, we discover relationships between spheres and diseases and determine the degrees of these relationships. We consider the level of HR-QoL experienced in each sphere and evaluate their influence in a given disease before and at age 65 and older.

MATERIALS AND METHOD

Organization of the study

A cross – sectional study was conducted in Poland with a group of 8,967 patients, of whom 7,620 were ultimately included in the analyses. Incomplete data and records incorrectly filled in by patients have been removed. The individual stages of the study are presented in flow chart. (Fig. 1)

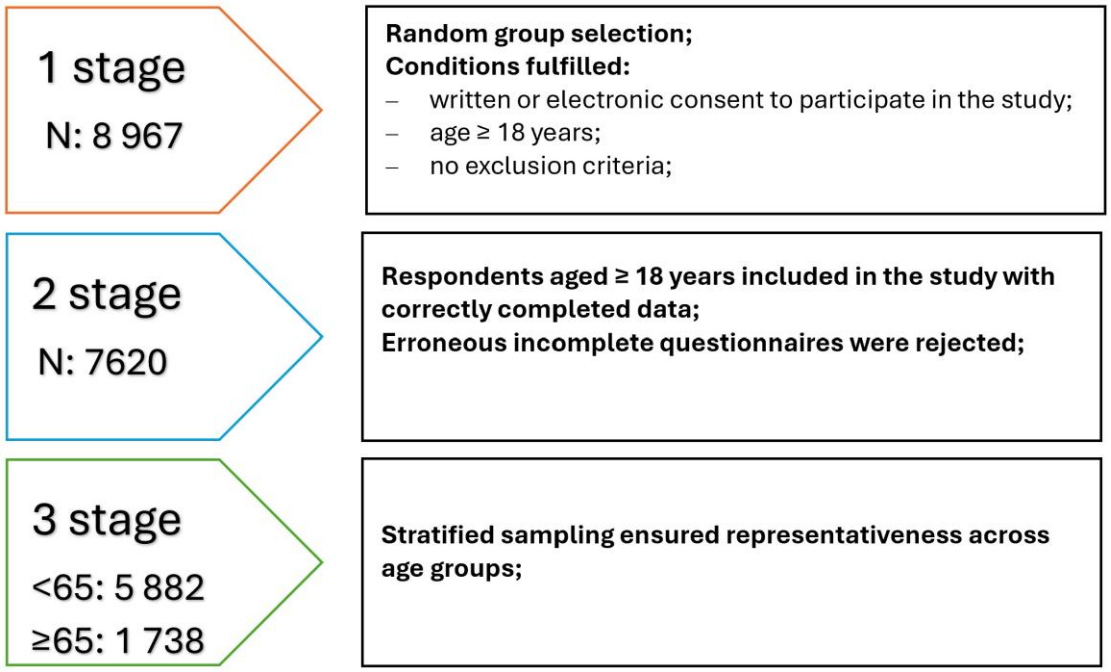

Figure 1. Flow chart.

The study included 13 groups of patients presented in Table 1. The study was voluntary and anonymous. Before starting the study, the respondents were informed about the purpose of the study, the purpose of the results, the absence of risk in the study and the possibility of withdrawing from the study at any stage of its duration.

The study was based on the completion of a standardized questionnaire for assessing quality of life SF – 36 supplemented by a questionnaire of our own design, which allowed to obtain sociodemographic and basic data to verify the inclusion criteria for the study. The study included double verification of the diagnosed chronic disease in a given patient participating in the study. The first stage of verification was the fact that the patient was being treated at a specialist clinic for a given chronic disease. The next stage was the verification of other diseases through questions asked in the questionnaire to rule out other chronic diseases. If the respondent indicated that they had only one chronic disease, but in the additional questions they indicated another chronic disease, they were removed from further analysis.

Table 1. Disease groups and their abbreviations.

Disease groups	Abbreviations
Cancers	CD
Cardiovascular disease	CVD
Diabetes mellitus	DM
Disease of digestive system	DS
Degenerative changes of the cervical spine	DSD-C
Degenerative changes of the lumbosacral spine	DSD-LS
Degenerative changes of the thoracic spine	DSD-Th
Ophthalmic diseases	ED
ENT diseases	LD
Diseases of the nervous system	NS
Respiratory diseases	RS
Thyroid diseases	TD
Diseases of the kidneys and urinary system	UD

A positive opinion was obtained from the Commission on Ethics of Scientific Research of the University of Information Technology and Management in Rzeszow (2/2022).

The study was carried out in accordance with the Helsinki Declaration (WMA Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects) [14].

Study group

The study was conducted among 7,620 patients from 13 disease groups. Inclusion criteria for the study were: age ≥18 years, chronic disease treatment ≥2 years, no other diseases and/or coexisting chronic symptoms. Subjects were assigned to specific disease groups based on the results of the questionnaire and the indication of only one chronic disease for which they were being treated. Data regarding gender, place of residence, and education level of the studied group, divided into two age groups (<65 and ≥65), is presented in Table 2.

Table 2. General characteristics of the study group of the respondents.

Characteristics	Age group				Total [7620; 100,0]	
	<60 years		≥65 years			
	n	%	n	%	n	%
Gender: female/male	3344/2538	56,9/43,1	859 / 879	49,5 / 50,6	4203/3417	55,2/44,8
Place of residence city/village	363 /2251	61,7/38,3	1017/721	58,5/41,5	4648/2972	61,0/39,0
Education: higher /secondary/elementary	2695/2674/513	45,8/45,5/8,7	305/915/518	17,5/52,6/29,8	3000/3589/1031	39,4/47,1/13,5

n - number of observations; % - percent

Questionnaire SF – 36

The study included an analysis of HR–QoL, which was conducted using the standardized SF–36 questionnaire to assess QoL. A license for using the tool was obtained (License Number: QM039882). The tool allowed for the assessment of quality of life in domains presented in Table 3. The individual domains were assigned to two main dimensions of QoL according to the tool's key [5] as follows: PF + RP + BP + GH form the Physical Component Summary (PCS). VT + SF + RE + MH form the Mental Component Summary (MCS). Both of these dimensions – PCS and MCS – constitute the Index of Life Quality (ILQ)[15].

Table 3. Spheres and their abbreviations

Spheres	Abbreviations
Physical functioning	PF
Role physical	RP
Bodily pain	BP
General health	GH
Vitality	VT
Social functioning	SF
Role emotional	RE
Mental health	MH
Subjective sense of change in health	Hch
Physical Component Summary	PCS
Mental Component Summary	MCS
Index of Life Quality	ILQ

Methodology

The applied methodology consists of four consecutive stages, illustrated in Figure 2.

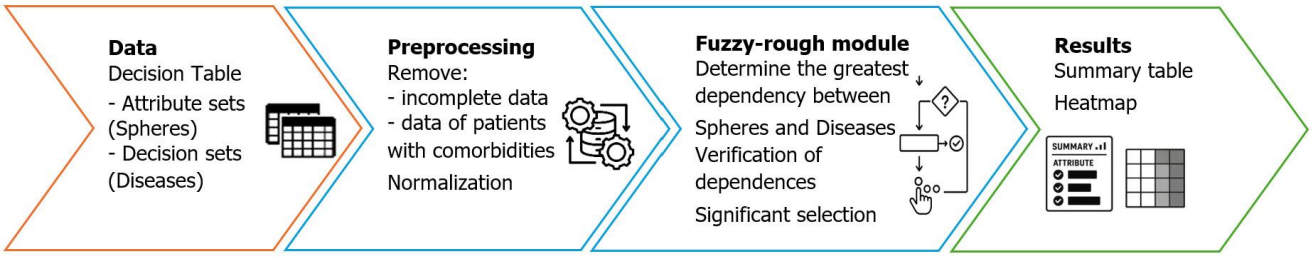

Figure 2. Stages of the proposed methodology Fuzzy relational equations and inequalities.

The first stage, Data, addresses the technical aspects of structuring information into a decision table format, a common approach in machine learning. The second stage, Preprocessing, involves standard procedures to prepare the dataset for analysis, including the removal of incomplete records and patients with comorbidities, as well as data normalization. The core analytical stage, the Fuzzy-rough module, is discussed in detail in this chapter. It enables the determination of the degree of relationship between attributes (spheres) and diseases, as well as the identification of those with the strongest associations. The final stage of the methodology presents the results in the form of summary tables and heatmaps.

We consider data set in the form of decision table [2]. An example of the decision table is presented in Table 4.

Table 4. A data set.

Cases	**Attributes** (spheres)				**Decision**
	VT	SF	RE	MH	Disease
1	30	37.5	33.33	52	CD
2	50	37.5	66.67	64	CD
3	20	25	0	24	CD
4	35	25	33.33	64	CD
5	25	37.5	66.67	28	DM
6	75	100	100	52	DM
7	70	87.5	100	56	DM
8	55	62.5	66.67	56	DM

The decision table is a system consisting of a non-empty, finite set of Cases, *Attributes* (spheres), and *Decision* (disease). The *Cases* in the decision table represent respondents' responses. In Table 1 vitality – VT, social functioning – SF, role emotional – RE and mental health – MH are *Attributes*. The dependent variable Disease is called *Decision*. In Table 1, there are two concepts, the set {1, 2, 3, 4} of all cases for which the value of Disease is *CD* – cancers and the set {5, 6, 7, 8} for which the value of Disease is *DM* – diabetes mellitus.

Since the collected descriptive attributes are percentiles, these values are not subject to the normalization process. Percentages need to be converted to decimal numbers.

Since we are looking for attributes that most strongly influence the quality of life in each disease (decision), we measure of central tendency degree for each examined case, i.e.:

$$d_i = AVG(a_{ij}),\ \ i \in M, \qquad (1)$$

where $a \in Attribute$, $|Attributes|=n$ – number of attributes, $N=\{1,\ldots,n\}$, $m = |Cases|$ – $number\ of\ cases, and\ M = \{1, \ldots, m\}$

The fuzzified data set is presented in Table 5.

Table 5. The fuzzified data set.

Cases	**Attributes**				**Decison**
	VT	**SF**	**RE**	**MH**	**Disease**
1	0.3	0.37	0.33	0.52	0.38
2	0.5	0.37	0.67	0.64	0.54
3	0.2	0.25	0	0.24	0.17
4	0.35	0.25	0.33	0.64	0.39
5	0.25	0.37	0.67	0.28	0.39
6	0.75	1	1	0.52	0.82
7	0.7	0.87	1	0.56	0.78
8	0.55	0.62	0.67	0.56	0.6

For a specific matrix A and a vector d the *fuzzy relational equations* are defined as follows:

$$A \circ x = d$$

where the following fuzzy relations are given:

$$A: Cases \times Attribute \rightarrow [0,1]^{m \times n},$$
$$d: Cases \times Decisions \rightarrow [0,1]^{m}$$

and the unknown relation is

$$x: Attributes \times Decisions \rightarrow [0,1]^{\wedge}n.$$

The fuzzy matrix A $[0,1]^{m\times n}$ represents the degree to which each object satisfies a specific attribute, the vector d $[0,1]^m$ represents the degree of confidence in the decision for a given object. Additionally, the unknown vector x $[0,1]^n$ represents the degrees of relationship between attributes and decisions.

Only the greatest solution of fuzzy relational equations $A \circ x = d$ is desirable. Therefore, the study can be conducted for all diseases separately. This approach allows for better insight into the relationships between attributes and disease.

Example 1. For Table 5, the fuzzy matrices and vectors for CD and DM diseases are as follows:

$A^{CD} = [0.30\ 0.38\ 0.33\ 0.52\ 0.50\ 0.38\ 0.67\ 0.64\ 0.20\ 0.25\ 0.00\ 0.24\ 0.35\ 0.25\ 0.33\ 0.64\ ]$,
$d^{CD} = [0.38\ 0.55\ 0.17\ 0.39\ ]$,
$A^{DM} = [0.25\ 0.38\ 0.67\ 0.28\ 0.75\ 1.00\ 1.00\ 0.52\ 0.70\ 0.88\ 1.00\ 0.56\ 0.55\ 0.63\ 0.67\ 0.56\ ]$,
$d^{DM} = [0.40\ 0.82\ 0.79\ 0.60\ ]$.

According to the results presented in [13], the study was carried out for *max-T* type equation systems. However, it should be emphasized that such considerations can be carried out taking into account wide range of operations (see [16]).

Our main goal is to identify the most important attributes that significantly impact the disease. Simultaneously the degree of the impact should be determined, as follows:

Step 1. Determine the greatest relationship between attributes and the disease. Identify the greatest solution:

$$u_j^{disease} = u_j(A, b, *) = a_{ij}^{disease} \rightarrow d_i^{disease}, j \in N,$$

where $\rightarrow$ is induced implication by operation $*(a \rightarrow d = max\{t \in [0,1]: a * t \leq d\}$, where $a, d \in [0,1]$, see [13,16]). For data from Table 4, it is obtained

$$d^{CD} = [0.80\ 0.75\ 0.55\ 0.39],$$
$$d^{DM} = [1.00\ 0.60\ 0.4\ 01.00].$$

Five types of relational compositions were considered in [3]: max-min, max-Einstein, max-Fodor, max-product, and max-Łukasiewicz. Experiments revealed that the highest accuracy was achieved using the max-Fodor one. Therefore, this multiplication method will be used for further analyses. For fuzzy matrices and vectors for *CD* and *DM* diseases from Example 1, the max-Fodor multiplication is a unit vector.

Step 2. Determine a binarized, reduced matrix A(disease)''. Identify attributes that influence the decision:

$$aij'' = \begin{cases} 1 & when\ aij * uj = di \\ 0 & in\ other\ case \end{cases}, \quad i \in M, j \in N.$$

From Example 1 and Step 1 we obtained:

$$A(CD)'' = [0\ 1\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ ]$$
$$A(DM)'' = [0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ ]$$

Step 3. Determine the relationship validity vector dc:

$$dc_j^{desease} = \frac{\sum_{i\in M} a(disease)_{ij}''}{m_{disease}}, j \in N.$$

The relationship validity vector, presented in Table 6, defines the degree of relationship between attributes (spheres) and disease (Table 6).

The differentiating factor for HR–QoL were two age groups: under 65 years of age (group 1) and 65 years and over (group 2).

It should be emphasized that the effectiveness of the proposed methodology, in comparison with established feature reduction methods, has been confirmed and published in [13]. At the same time, in the context of health-related quality of life research, where data are often imprecise, subjective, and fuzzy, attribute reduction based on fuzzy relational equations and inequalities offers clear advantages over classical approaches. While well-known PCA [17] reduces dimensionality at the expense of interpretability, and regression [18] assumes specific functional relationships, the proposed method retains the original attributes and explicitly incorporates uncertainty, making it particularly suitable for analyzing subjective and linguistically expressed health data.

Table 6. The relationship validity vector.

Cases	VT	SF	RE	MH
dc^{CD}	0	0.25	0.25	0
dc^{DM}	0	0.25	0.25	0

Statistical analysis

Measurable variables were presented using: mean (M), standard deviation (SD), minimum (Min) and maximum (Max) value, quartile: lower (Q1), mean (Q2) and upper (Q3). The difference between individual values of the SF-36 spheres (R) was marked. The compliance of the distribution of measurable variables with the normal distribution was assessed using the W-Shapiro Wilk test. A test was performed between two age groups (<65 and ≥65) by assessing the differences in the mean level in individual SF-36 spheres using the Student's t test. The relationships were considered statistically significant if

the significance level was $p \leq 0.05$. The analysis was performed using the Statistica 13.0 PL program.

Based on the results regarding the degree of dependence between spheres and diseases (see Table 7), the data were aggregated separately for each sphere, for individuals below and above the age of 65. The resulting clusters group together diseases with the most similar degrees of dependence. The applied Ward clustering method ensures that the clusters are internally coherent — that is, they are characterized by high intra-cluster similarity.

The statistical analysis was supplemented with reporting Hedges' g, as this measure provides information on the magnitude and direction of the effect, allowing for a better assessment of the practical significance of differences than p-values alone.

RESULTS

The main objective of our research is to discover spheres that correlate most strongly with a given disease entity and to indicate the degree of these relationships. Normalized data was divided into two age groups: under 65 years old (<65) and at age 65 and over (≥65). The groups were separated by disease entities. Therefore, 13 sets of data were analyzed in each group. To determine the degree of relationships the max-Fodor relational composition type was taken into account according to the methodology described in Section 1.4. The discovered relationships were presented at Figure 4 (under 65 years old) and Figure 5 (65 years old and over). Additionally, as a benchmark, Figure 3 shows the degree of the relationship between the spheres and the disease entity without considering the age category.

Figure 3. The degree of relationship between perceived HR- QoL in the spheres and diseases. BP – bodily pain, GH – general health, HCh – Subjective sense of change in health, MH – mental health, PF –physical functioning, RE – role emotional, RP – role physical, SF – social functioning, VT – vitality, MCS – Mental Component Summary, PCS – Physical Component Summary, ILQ SF-36 – Index of Life Quality, CD –cancers, CVD – cardiovascular disease, DM – diabetes mellitus, DS – disease of digestive system, DSD-C – degenerative changes of the cervical spine, DSD-LS – degenerative changes of the lumbosacral spine, DSDTh – degenerative changes of the thoracic spine, ED – ophthalmic diseases, LD – ENT diseases, NS –diseases of the nervous system, RS – respiratory diseases, TD – thyroid diseases, UD – diseases of the kidneys and urinary system.

The heatmap shows the correlation matrix between SF-36 domains and diseases. The colors represent the strength of the relationships between the variables – the more red, the stronger the positive correlation; the more blue, the weaker or negative the correlation.

Correlation analysis of the total study group showed very strong correlations between: LD-RP (0.84), DSD-

Th-RP (0.75), DSD-C-RP (0.73), UD-BP (0.72), NS-RE (0.69). Moderate correlations (0.5 - 0.7) were noted between the variables: CD - RP (0.59), CVD - RE (0.54), ED - RP (0.52), DM - RE (0.52), NS - RP (0.57), NS - SF (0.55). In contrast, weak correlations were noted between: LD - BP (0.04), LD - GH (0.12), LD - VT (0.03), TD-BP (0.06), TD-GH (0.03), TD-VT (0.04), DSD-LS-GH (0.12), DSD-LS-MH (0.10) (Fig. 3).

Correlation analysis in the group of patients before 65 years of age indicated a strong correlation between the variables: LD-RE (0.88), DSD-C-RP (0.75). Moderate correlations were indicated in DSD-LS-RP (0.67), TD-RE (0.67), DM-RE (0,66), DSD-Th-MH (0.61), NS-RE (0.62), UD-BP (0.61), CD-RP (0.53), ED-RP (0.51), CVD-RP (0.49). Low correlation was shown between pairs of variables: NS-RP (0.50), NS-SF (0.47), LD-BP (0.02), LD-GH (0.06), LD-VT (0.05), moreover, no higher values than 0.2 were noted for RS and DM (with one exception-RE) (Fig. 4).

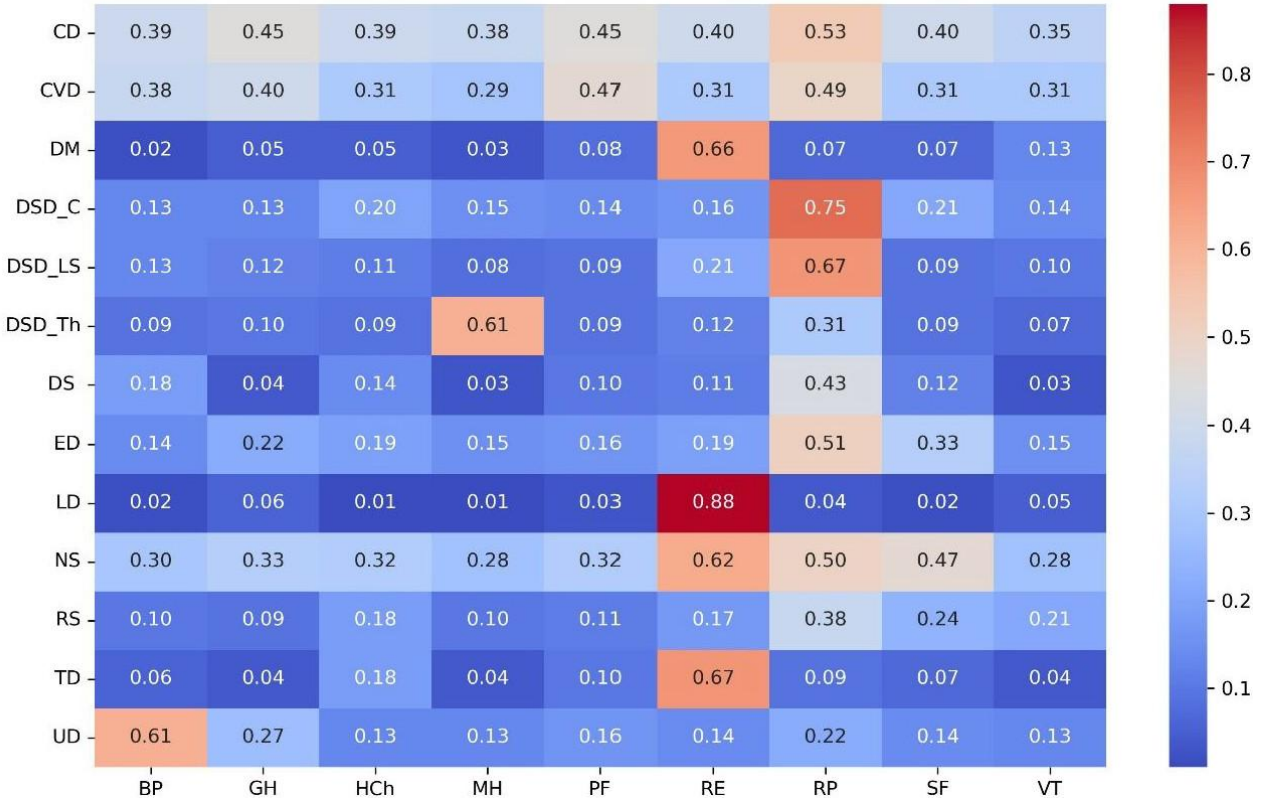

Figure 4. The degree of relationship between perceived HR- QoL in the spheres and diseases in group of patients under 65 years old. BP – bodily pain, GH – general health, HCh – Subjective sense of change in health, MH – mental health, PF – physical functioning, RE – role emotional, RP – role physical, SF – social functioning, VT – vitality, MCS – Mental Component Summary, PCS – Physical Component Summary, ILQ SF-36 – Index of Life Quality, CD – cancers, CVD – cardiovascular disease, DM – diabetes mellitus, DS – disease of digestive system, DSD-C – degenerative changes of the cervical spine, DSD-LS – degenerative changes of the lumbosacral spine, DSDTh – degenerative changes of the thoracic spine, ED – ophthalmic diseases, LD – ENT diseases, NS – diseases of the nervous system, RS – respiratory diseases, TD – thyroid diseases, UD – diseases of the kidneys and urinary system.

Correlation analysis among patients aged 65 and older indicated strong correlations between pairs of variables: NS-HCh (0.78) and NS-BP (0.70). Moderate correlations were indicated between variables: NS - RP (0.68), UD-BP (0.68), NS-PF (0.67), NS-RE (0.67), NS-GH (0.64), LD-RP (0.65), CD-PF (0.64), DSD-Th-RP (0.61), CD-RP (0.60), CVD-PF (0.58), CD-VT (0.55), DM-RP (0.54), DS-PF (0.52), DS-RE (0.52). Low correlation was shown between pairs of variables: CVD-RP (0.47), ED-BP (0.48), ED-GH (0.45), DSD-LS-GH (0.13), DSD-LS-SF (0.13), RS-RP (0.26), RS-SF (0.32), RS-VT (0.29). For TD, most of the correlations in this disease group were below 0.2 (Fig. 5).

The mean values of perceived HR-QoL among patients from each disease group with each of the SF - 36 spheres (normalized data) are presented. The data were divided into two age groups under 65 and 65 and older. For cancer, the differences between the two age groups analyzed in each of the SF - 36 spheres except MH ($p=0.826$) were statistically significant ($p<0.001$). The highest mean level of reduced perceived HR - QoL between groups was noted in PF (-0.18; $p<0.001$) and RP

(-0.17%; p<0.001). For CVD, there was no significant relationship only in the HCh sphere (p=0.945). The highest mean level of deterioration in perceived HR - QoL between groups was noted in PF (-0.12; p<0.001) and RE (-0.14; p<0.001). Significantly greater differences in the perceived level of HR - QoL in the two compared groups were noted in DM.

Figure 5 The degree of relationship between perceived HR- QoL in the spheres and diseases in group of patients aged 65 and over. BP – bodily pain, GH – general health, HCh – Subjective sense of change in health, MH – mental health, PF – physical functioning, RE – role emotional, RP – role physical, SF – social functioning, VT – vitality, MCS – Mental Component Summary, PCS – Physical Component Summary, ILQ SF-36 – Index of Life Quality, CD – cancers, CVD – cardiovascular disease, DM – diabetes mellitus, DS – disease of digestive system, DSD-C – degenerative changes of the cervical spine, DSD-LS – degenerative changes of the lumbosacral spine, DSD-Th – degenerative changes of the thoracic spine, ED – ophthalmic diseases, LD – ENT diseases, NS – diseases of the nervous system, RS – respiratory diseases, TD – thyroid diseases, UD – diseases of the kidneys and urinary system

The highest mean level of deterioration in perceived HR - QoL between the groups was noted in RP (-0.39; p<0.001), PF (-0.35; p<0.001) and RE (-0.33; p<0.001). Significant differences (p<0.001) were noted for DS in each sphere. The highest mean level of deterioration in perceived HR - QoL between groups was noted in PF (-0.29; p<0.001) and RP (-0.31; p<0.001). For DSD - C, DSD - Th and DSD - LS, the highest mean level of deterioration in perceived HR - QoL between groups was noted in RP (p<0.001) and RE (p<0.001). Those aged 65 and over indicated significantly lower levels of HR - QoL. In the ED, a significant reduction in HR - QoL in the group of people ≥ 65 years was noted in the RP (-0.23; p=0.002) and RE (-0.27; p=0.001) spheres. In LD, only in the MH sphere there was no significance (-0.03; p=0.218), in the other spheres significant differences between groups were indicated. The largest difference in HR - QoL reduction in the older group was noted in RP (-0.21; p<0.001). NS indicated significant differences between the study groups in each sphere. The highest reduction in HR - QoL among the ≥ 65 years group was noted in RE (-0.41; p<0.001), SF (-0.33; p<0.001) and BP (-0.32; p<0.001). In contrast, an increase in mean HR - QoL was noted in VT (+0.14; p<0.001) and MH (+0.13; p<0.001). In RS, small differences were noted between the groups analyzed. On the other hand, TD significantly reduced HR - QoL was noted in PF (-0.14; p<0.001), RP (-0.22; p=0.029) and RE (-0.21; p=0.043), while MH showed a slight improvement in HR - QoL (+0.05; 0.014). UD patients outside the MH sphere (+0.02; p=0.231) showed significant differences between the analyzed groups. Patients aged 65 and above always declared lower mean

HR - QoL. The largest differences were observed in RE (-0.29; p<0.001), BP (-0.23; p<0.001), PF (-0.21; p<0.001) and SF (-0.21; p<0.001) (see Table 7).

Table 7. The average level of perceived quality of life by patients in each sphere of SF – 36 (data normalized from percentage values).

Diseases	**SF – 36**								
CD									
<65 n=374)	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.50	0.29	0.44	0.41	0.57	0.52	0.26	0.58	0.59
SD	0.26	0.37	0.25	0.14	0.13	0.25	0.38	0.11	0.28
65≥ (n=177)	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.32	0.12	0.36	0.35	0.54	0.45	0.15	0.58	0.59
SD	0.23	0.26	0.24	0.12	0.13	0.23	0.31	0.12	0.29
R	-0.18	-0.17	-0.08	-0.06	-0.03	-0.07	-0.11	-0.0	-0.0
p	<0.001	<0.001	<0.001	<0.001	0.010	0.002	0.001	0.826	0.030
CVD									
<65 (n=308)	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.62	0.25	0.56	0.45	0.51	0.66	0.43	0.54	0.56
SD	0.25	0.34	0.25	0.14	0.12	0.24	0.42	0.11	0.31
65≥ (n=344)	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.50	0.14	0.47	0.41	0.47	0.55	0.29	0.51	0.56
SD	0.24	0.25	0.24	0.15	0.11	0.24	0.39	0.11	0.30
R	-0.12	-0.11	-0.09	-0.04	-0.04	-0.11	-0.14	-0.03	-0.0
p	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.946
DM									
<65 (n=283)	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.84	0.68	0.73	0.54	0.55	0.72	0.66	0.49	0.59
SD	0.21	0.41	0.22	0.14	0.15	0.23	0.43	0.15	0.30
65≥ (n=357)	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.49	0.29	0.52	0.45	0.43	0.60	0.33	0.43	0.54
SD	0.3	0.4	0.2	0.1	0.1	0.2	0.4	0.1	0.3
R	-0.35	-0.39	-0.21	-0.09	-0.12	-0.12	-0.33	-0.06	-0.05
	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.023
DS									
<65 (n=458)	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.87	0.38	0.56	0.51	0.53	0.70	0.48	0.50	0.70
SD	0.12	0.44	0.22	0.12	0.12	0.17	0.44	0.11	0.24
65≥ (n=178)	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.58	0.07	0.40	0.34	0.40	0.56	0.28	0.46	0.52
SD	0.19	0.23	0.20	0.12	0.14	0.17	0.41	0.11	0.17
R	-0.29	-0.31	-0.16	-0.17	-0.13	-0.14	-0.2	-0.04	-0.18
p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
DSD – C									
<65 (n=355)	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.79	0.65	0.60	0.58	0.61	0.77	0.76	0.63	0.60
SD	0.21	0.43	0.26	0.25	0.19	0.22	0.38	0.17	0.31
65≥ (n=28)	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.55	0.23	0.48	0.43	0.48	0.66	0.40	0.49	0.48
SD	0.23	0.35	0.21	0.20	0.13	0.18	0.41	0.13	0.32
R	-0.24	-0.42	-0.12	-0.15	-0.13	-0.11	-0.36	-0.14	-0.12
p	<0.001	<0.001	0.017	0.003	<0.001	0.006	<0.001	<0.001	0.052
DSD – Th									
<65 (n=509)	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.87	0.69	0.71	0.57	0.58	0.76	0.79	0.58	0.48
SD	0.19	0.37	0.23	0.20	0.17	0.23	0.36	0.14	0.20
65≥ (n=100)	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.61	0.29	0.53	0.44	0.50	0.62	0.5	0.53	0.45
SD	0.27	0.37	0.24	0.15	0.17	0.24	0.43	0.15	0.18
R	0.26	0.4	0.18	0.13	0.08	0.14	0.29	0.05	0.03
p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.066
DSD – LS									

<65 *(n=344)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.78	0.64	0.59	0.57	0.58	0.74	0.73	0.59	0.62
SD	0.18	0.41	0.23	0.21	0.16	0.21	0.40	0.15	0.30
65≥ *(n=63)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.63	0.43	0.57	0.49	0.59	0.69	0.55	0.55	0.64
SD	0.27	0.42	0.22	0.20	0.13	0.19	0.43	0.14	0.29
R	-0.15	-0.21	0.02	0.08	-0.01	0.05	0.18	0.04	-0.02
p	<0.001	<0.001	0.629	0.007	0.908	0.078	0.002	0.049	0.521
ED									
<65 *(n=650)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.63	0.45	0.57	0.51	0.50	0.67	0.62	0.47	0.62
SD	0.25	0.42	0.22	0.17	0.12	0.28	0.45	0.12	0.31
65≥ *(n=33)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.44	0.22	0.49	0.40	0.49	0.65	0.35	0.51	0.54
SD	0.27	0.38	0.25	0.14	0.12	0.26	0.43	0.11	0.22
R	-0.19	-0.23	-0.08	-0.11	-0.01	-0.02	-0.27	+0.04	-0.08
p	<0.001	0.002	0.028	<0.001	0.384	0.744	0.001	0.118	0.143
LD									
<65 *(n=520)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.94	0.86	0.88	0.59	0.49	0.89	0.87	0.45	0.59
SD	0.11	0.32	0.20	0.15	0.13	0.16	0.29	0.16	0.22
65≥ *(n=80)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.80	0.65	0.77	0.48	0.45	0.81	0.70	0.42	0.49
SD	0.23	0.46	0.26	0.15	0.15	0.21	0.41	0.13	0.26
R	-0.14	-0.21	-0.11	-0.11	-0.04	-0.08	-0.17	-0.03	-0.1
p	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	0.218	<0.001
NS									
<65 *(n=600)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.50	0.31	0.59	0.39	0.42	0.56	0.53	0.43	0.64
SD	0.31	0.35	0.29	0.13	0.18	0.27	0.45	0.13	0.25
65≥ *(n=165)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.28	0.04	0.27	0.33	0.56	0.23	0.12	0.56	0.48
SD	0.21	0.17	0.24	0.08	0.05	0.22	0.30	0.06	0.23
R	-0.22	-0.27	-0.32	-0.06	+0.14	-0.33	-0.41	+0.13	-0.16
p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
RS									
<65 *(n=544)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.69	0.37	0.66	0.35	0.52	0.63	0.39	0.54	0.62
SD	0.21	0.41	0.20	0.12	0.15	0.26	0.44	0.19	0.20
65≥ *(n=90)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.58	0.20	0.50	0.34	0.57	0.49	0.29	0.57	0.60
SD	0.24	0.27	0.22	0.11	0.12	0.21	0.34	0.12	0.24
R	-0.11	-0.17	-0.16	-0.01	+0.05	-0.14	-0.1	+0.03	-0.02
p	<0.001	<0.001	<0.001	0.967	0.002	<0.001	0.033	0.115	0.506
TD									
<65 *(n=411)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.89	0.64	0.72	0.49	0.52	0.75	0.65	0.48	0.65
SD	0.13	0.42	0.23	0.13	0.09	0.22	0.45	0.09	0.29
65≥ *(n=19)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.75	0.42	0.73	0.48	0.54	0.81	0.44	0.53	0.58
SD	0.20	0.43	0.21	0.09	0.11	0.19	0.50	0.09	0.31
R	-0.14	-0.22	+0.01	-0.01	+0.02	+0.06	-0.21	+0.05	-0.07
p	<0.001	0.029	0.905	0.665	0.506	0.288	0.043	0.014	0.295
UD									
<65 *(n=526)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.82	0.71	0.66	0.49	0.51	0.79	0.73	0.47	0.70
SD	0.27	0.41	0.29	0.13	0.11	0.29	0.40	0.12	0.24
65≥ *(n=104)*	**PF**	**RP**	**BP**	**GH**	**VT**	**SF**	**RE**	**MH**	**HCh**
M	0.61	0.41	0.43	0.41	0.48	0.58	0.44	0.49	0.59
SD	0.29	0.44	0.27	0.14	0.14	0.32	0.46	0.13	0.26
R	-0.21	-0.3	-0.23	-0.08	-0.03	-0.21	-0.29	+0.02	-0.11
p	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	0.231	<0.001

BP – bodily pain. GH – general health. HCh – Subjective sense of change in health. MH – mental health. PF – physical functioning. RE – role emotional. RP – role physical. SF – social functioning. VT – vitality. MCS – Mental Component Summary. PCS – Physical Component Summary. ILQ SF-36 – Index of Life Quality. CD – cancers. CVD – cardiovascular disease. DM – diabetes mellitus. DS – disease of digestive system. DSD-C – degenerative

changes of the cervical spine. DSD-LS – degenerative changes of the lumbosacral spine. DSD-Th – degenerative changes of the thoracic spine. ED – ophthalmic diseases. LD – ENT diseases. NS – diseases of the nervous system. RS – respiratory diseases. TD – thyroid diseases. UD – diseases of the kidneys and urinary system. 100% – is the best perceived QoL level; M -average; SD- standard deviation; Min- minimum value; Q1 – lower quartile; Q2 -mean quartile; Q3 -upper quartile; Max -maximum value; R – difference between groups '<60' and '65≥'; p – significant level, test t Student; data normalized from percentage values: 100% =1.0; 50%=0,50; 10%=0.10.

Complementing the analyses (see Table 7) is a clustering of diseases for individual spheres in the two analysed age groups. The clustering shows which groups of diseases (clusters) present similarity in perceived HR - QoL in the individual spheres analysed in the SF - 36. Most of the analyses indicated two clusters, which means that the quality of life in individual clusters is similar, while differences in perceived HR - QoL (better and worse perceived HR - QoL) can be identified between clusters (Table 8).

Table 8. Hedges' g values and interpretation of effect sizes.

Disease	PF		RP		BF		GH		VT		SF		RE		MH		MCh	
	Hg	E	Hg	E	Hg	E	Hg	E	Hg	E	Hg	E	Hg	E	Hg	E	Hg	E
CVD	0.49	S	0.37	S	0.37	S	0.27	S	0.35	S	0.46	S	0.35	S	0.27	S	0.00	N
DSD–C	1.13	L	0.99	L	0.47	S	0.61	M	0.70	M	0.50	M	0.94	L	0.83	L	0.39	S
DSD–LS	0.76	M	0.51	M	0.09	N	0.38	S	-0.06	N	0.24	S	0.44	S	0.27	S	-0.07	N
DSD–Th	1.27	L	1.08	L	0.78	M	0.67	M	0.47	S	0.60	M	0.78	M	0.35	S	0.15	N
DM	1.32	L	0.96	L	1.00	L	0.75	M	0.96	L	0.56	M	0.80	M	0.48	S	0.17	N
DS	2.03	L	0.79	M	0.74	M	1.41	L	1.03	L	0.82	L	0.46	S	0.36	S	0.81	L
NS	0.75	M	0.84	L	1.14	L	0.50	S	-0.87	NL	1.27	L	0.97	L	-1.10	NL	0.65	M
LD	1.06	L	0.61	M	0.53	M	0.73	M	0.30	S	0.48	S	0.55	M	0.19	N	0.44	S
RS	0.51	M	0.43	S	0.79	M	0.08	N	-0.34	NS	0.55	M	0.23	S	-0.16	N	0.10	N

S-small; M- medium; L– large; N - negligible; NS - negative small; NL - negative large; Hg - Hedges'g; E - effect

The clustering shows which groups of diseases (clusters) present similarity in perceived HR - QoL in the individual spheres analysed in the SF - 36. Most of the analyses indicated two clusters, which means that the quality of life in individual clusters is similar, while differences in perceived HR - QoL (better and worse perceived HR - QoL) can be identified between clusters. Detailed results of the analysis and individual disease groups are presented in Table 9. In the PF sphere in the under 65 years group, similarity in perceived HR-QoL was noted in the disease group: CVD, CD and NS. Among respondents 65 years and over, DS was also included in this disease cluster. Diseases assigned to this cluster decreased HR - QoL more strongly in patients from the given disease units compared to diseases assigned to the other cluster. In the sphere of RP in the younger group, the analysis identified two clusters. The disease cluster in which lower HR - QoL was recorded included: RS, DS, NS, ED, CVD, CD, DSD-LS, DSD-C. In contrast, the disease group for older patients included: DS, UD, DM, LD, DSD-Th. Only TD and RS slightly reduced HR - QoL in the RP sphere, whereas the other disease entities significantly reduced HR - QoL in the group of patients 65 years and older. In the BP domain in the younger group, the diseases that most severely reduced HR- QoL were: CVD, CD, NS, UD. In the older group of patients, the following diseases that lowered HR-QOL were included: DS, ED, DSD-C, DSD-Th, DM. The group of diseases that reduced HR - QoL in the GH sphere among the younger group were: UD, ED, NS, CVD, CD. In the older patients, the group of diseases included: DSD-C, DM, DS, DSD-Th, RS. The strongest HR - QoL in the VT sphere among younger subjects was reduced by the following disease group: CD, CVD, NS. Among the elderly, the group of diseases most strongly decreasing HR - QoL included: NS and CD. HR- QoL was least affected by: LD, DSD-LS, TD. For the SF sphere in the younger patient group, the strongest decreases in HR - QoL were disease group: RS, DSD-C, ED, CVD, NS, CD. Among the older patients, only TD and RS slightly reduced HR - QoL, the other diseases similarly correlated with a reduction in HR - QoL. HR - QoL in the RE sphere among patients under 65 years of age was decreased by the following diseases: RS, DSD-C, UD, DS, DSD-Th, ED, DSD-Th, ED, DSD-LS, CVD, CD. In the group of older patients, diseases lowering HR-QoL included: DSD-Th, CD, DS, NS, TD, DSD-C, UD, DM, CVD. In the MH domain in the under 65 years group, the lowest HR - QoL was reported among the following disease group: NS, CVD, CD, DSD-Th. In older patients, it was NS and CD that most severely reduced HR - QoL. The lowest HR - QoL among the younger group in the HCh sphere was noted in: NS, CVD, CD. In the other group, it was CD and NS that most strongly decreased HR – QoL.

DISCUSSION

The importance of age in subjective sense of quality of life needs no emphasis. A large body of scientific evidence supports this factor as important in reducing

perceived HR - QoL especially among those affected by chronic disease [19). Age tends to be a contributing factor to increased risk of both disease and poorer health, disease course and less effective treatment due to a cascade of body changes in various systems [19–21]. In contrast, chronic diseases, whose prevalence rates are rapidly increasing, are a global problem, contributing to death and significant disability in the population, especially as the years go by [22]. Poor self-medication skills of patients, and consequently poor control of chronic diseases, contribute to lower overall quality of life [23]. There is a need for an integrated approach to chronic diseases, but the success and desirability of such efforts in public health and health systems can only be effective if we analyze groups of diseases, find common features for those diseases that significantly reduce quality of life. Then coordinated actions can be targeted at specific disease groups, reducing costs and at the same time increasing the effectiveness of the measures applied.

Table 9. Groups of diseases with the strongest and weakest impact on patients' HR-QoL. Ward clustering method.

Spheres SF – 36	Diseases with the strongest and weakest impact on health-related quality of life (HR-QoL)	
	< 65 years	≥ 65 years
PF	CVD, CD, NS (minor: TD, DS, RS, DSD-Th, DSD-LS, DM, LD, UD, ED, DSD-C)	DS, CVD, NS, CD (minor: ED, DSD-C, RS, UD, DM, DSD-Th, LD, DSD-LS, TD)
RP	CVD, CD, NS, RS, DS, ED, DSD-LS, DSD-C (minor: UD, DSD-Th, TD, DM, LD)	DS, CVD, CD, DSD-LS, ED, UD, DM, DSD-C, NS, LD, DSD-Th (minor: TD, RS)
BP	CVD, CD, NS, UD (minor: RS, DSD-Th, TD, LD, DM, DSD-LS, DSD-C, ED, DS)	DS, CVD, CD, UD, NS, ED, DSD-C, DSD-Th, DM (minor: LD, DSD-LS, RS, TD)
GH	UD, ED, NS, CVD, CD (minor: RS, DSD-Th, DSD-LS, DSD-C, LD, DM, TD, DS)	DSD-C, DM, UD, DS, DSD-Th, ED, RS, CD, CVD, NS (minor: TD, DSD-LS, LD)
VT	NS, CVD, CD, (minor: ED, DSD-C, UD, DM, RS, DSD-Th, DSD-LS, TD, LD, DS)	NS, CD, (moderately: UD, DSD-Th, DSD-C, DS, CVD, ED, DM, RS; minor: LD, DSD-LS, TD)
SF	RS, DSD-C, ED, CVD, NS, CD, (minor: DSD-Th, DSD-LS, TD, DM, LD, UD, DS)	DS, CVD, DSD-C, DSD-Th, DSD-C, ED, UD, DM, NS, LD, CD (minor: TD, RS)
RE	CD, CVD, RS, DSD-C, UD, DS, DSD-Th, ED, DSD-LS (minor: TD, DM, NS, LD)	DM, CVD, DSD-Th, CD, DS, NS, TD, DSD-C, UD (minor: LD, DSD-LS, RS, ED)
MH	NS, CVD, CD, DSD-Th (minor: ED, DSD-C, UD, RS, DSD-LS, DS, DM, TD, LD)	NS, CD (moderately: ED, DM, DSD-C, RS, UD, LD, DS, DSD-Th, CVD; minor: TD, DSD-LS)
HCh	NS, CVD, CD (minor: DSD-Th, DSD-LS, UD, DS, ED, DSD-C, TD, RS, LD, DM)	CD, NS (minor: RS, DSD-LS, TD, LD, UD, DM, ED, DS, DSD-Th, DSD-C, CVD)

BP – bodily pain. GH – general health. HCh – Subjective sense of change in health. MH – mental health. PF – physical functioning. RE – role emotional. RP – role physical. SF – social functioning. VT – vitality. MCS – Mental Component Summary. PCS – Physical Component Summary. ILQ SF-36 – Index of Life Quality. CD – cancers. CVD – cardiovascular disease. DM – diabetes mellitus. DS – disease of digestive system. DSD-C – degenerative changes of the cervical spine. DSD-LS – degenerative changes of the lumbosacral spine. DSD-Th – degenerative changes of the thoracic spine. ED – ophthalmic diseases. LD – ENT diseases. NS – diseases of the nervous system. RS – respiratory diseases. TD – thyroid diseases. UD – diseases of the kidneys and urinary system.

The sub-analysis presented by the authors complements earlier general analyses by age group [10]. It should be emphasised that the authors' previous publications concern the analysis of quality of life in many age groups, with the assessment of differences between groups using statistical methods. In the current study, the authors used reference points below 65 years of age and 65 years and above to verify the level of perceived HR-QoL in the working-age group and among seniors. When comparing these two groups, the fuzzy rough method was used, which was crucial.

Fuzzy logic models the uncertainty and imprecision inherent in data. This type of modeling differs fundamentally from traditional statistical approaches. Fuzzy logic addresses the vagueness of concepts, whereas statistics deals with the randomness of events. In fuzzy logic, values in the range [0,1] represent degrees of truth, while in statistics, they indicate the likelihood of an event occurring. Although the two approaches can complement each other, they serve different purposes: fuzzy logic is better suited for modeling natural language (in our case, respondents' answers), whereas statistics is primarily used to analyze empirical data and estimate risk.

Analyzing the level of HR - QoL emphasizes the importance of mental and physical dimensions in the overall perception of quality of life for people of all ages. The younger age group is more likely to have different disease entities compared to the elderly, as well as the level of acceptance of the disease, the body's repair capacity, endo and exogenous factors. Among the elderly burdened with mental disorders, persistent inflammation can be observed, which is characteristic of the immune process of aging, and which can worsen health, including mental health [24]. In addition, the social isolations applied in recent years related to the reduction of COVID - 19 infections have resulted in a deterioration of mental health among the societies of the countries, both among the younger and older population [25–27].

In the authors' study in a younger group under 65 years of age, the diseases that most severely reduce HR - QoL included: CD, CVD and NS. The same group of diseases also appears in the group of patients aged 65 and older, but they are joined by other disease entities in different configurations depending on the analyzed sphere of SF - 36. Although other groups of diseases also appear in the younger group, they do not negatively affect the perception of the level of HR - QoL, as the 3 main groups (CD, CVD, NS).

In the group of patients under the age of 65, CD, CVD and NS were among the diseases that lower HR - QoL in the following spheres: PF, RP, BP, GH, VT, SF, MH and HCh. HR - QoL in the RE sphere was most severely lowered by CD and CVD, which means that CD and CVD are the disease groups that most severely lower HR - QoL in each sphere in younger patients. This means that a reduction in HR - QoL will be recorded in each dimension, both physical and mental. Thus, interventions in these disease groups should include both interventions aimed at improving patients' physical functioning, their ability to fulfill daily responsibilities, self-care, ability to live independently, and interventions aimed at improving mental health. Studies emphasize the negative impact of the disease on mental health, the lack of acceptance of the disease, reduced well-being and even emerging mental disorders such as depression, neurosis or other types of illness, often resulting from maladaptation to existing conditions of functioning, altered as a result of chronic disease [28–31]. It is necessary to pay attention in public health measures to the mental health of patients, who, declaring a satisfactory level of HR - QoL in the mental dimension, will show a better level of acceptance of the disease, but also a satisfactory healing process can be observed. This is especially important in groups of patients with chronic diseases.

It is worth noting that the authors studied HR - QoL among patients with individual disease entities, without the additional burden of other diseases, in order to better assess how individual diseases affect HR - QoL. In contrast, a common phenomenon observed in older age groups is multimorbidity [32], which generates overlapping clinical problems, complex and long-term care needs, cognitive and functional impairment [33,34].

Analysis of HR - QoL in the group of patients 65 years and older indicates a much larger group of diseases that contribute to lower HR - QoL. It should be emphasized that the group of diseases: DSD-C, DM and DS appeared frequently, and that they significantly reduced HR-QoL. DM is a disease that reduces quality of life in various aspects due to the different effects of chronic disease [35]. Social functioning may be reduced among patients with diabetic retinopathy and neuropathy, and on the other hand, reduced HR - QoL related to physical functioning positively correlate with complications such as diabetic foot ulcer, diabetic nephropathy [36]. In the author's study, DM decreased HR - QoL in the spheres: RE, SF, VT, GH, BP, RP and moderately in the MH sphere. Thus, it was confirmed that functions related to social roles, emotions, vitality, experiencing disease-related pain and impaired physical function lowered HR - QoL in older (≥65 years) patients with DM.

Diseases related to the digestive system (DS) are also a significant problem in geriatrics. Studies confirm a reduction in the quality of life of patients with chronic diseases of the gastrointestinal tract, due to the occurrence of pain, cramps, fear of eating, problem with the process of digestion of food, and, along with these symptoms, psychological disorders such as depression, anxiety and others [37–39].

Own studies indicate a strong reduction in HR - QoL in the spheres: PF, RP, BP, GH, SF, RE and moderate reduction of HR - QoL in VT and MH, which means that chronic gastrointestinal diseases interfere with patients' social functions, as well as the fulfillment of physical roles, partially also noted reduced HR - QoL in the sense of mental health and vitality, which is often conditioned by a restricted diet, or cachexia due to disruption of the process of absorption of nutrients and vitamins.

The observed phenomenon of population ageing obliges countries to strengthen their health policy and disability prevention measures among older people, and to implement preventive measures to improve the perceived quality of life among people under 65, among whom chronic diseases are becoming increasingly common. Identifying significant correlations between disease and SF-36 domains will allow for the identification of domains with reduced HR-QoL and the implementation of corrective measures to increase HR-QoL. Increasing the availability of rehabilitation to improve physical function and psychological support for patients, who are often burdened with multiple diseases,

is important for increasing the perceived quality of life in the mental dimension. Patients with a high level of HR-QoL usually cope better with their illness and recover more quickly. Emphasising the importance and necessity of implementing psychological measures, especially in groups of patients with chronic conditions, is particularly important and leads to an increase in HR-QoL. Areas with reduced HR-QoL will allow for the planning of targeted measures and holistic treatment of patients in various clinics.

In summary, the analysis of each of the spheres and each group of diseases makes it possible to indicate which spheres are rated lower in each case, this will allow the proper management of public health measures. Meanwhile, the next stage of research will involve conducting detailed studies for each disease entity, identifying specific aspects of life that affect well-being or lack thereof. Especially, this will enable the analysis of other social factors such as diet and exercise, social and religious involvement, satisfaction (dissatisfaction) with healthcare, and many others within each socioeconomic group. Balanced fuzzy equation systems (see [40]) will be used for this purpose. These systems enable the study of relationships between characteristics and decisions of various kinds.

Limitation

The study also has some limitations. The authors did not analyse any factors related to disease, disease duration, treatment, etc. The aim of the study was a general validation of the level of HR - QoL in different disease groups, therefore a universal quality of life assessment tool SF - 36 was used, rather than dedicated tools to assess quality of life in individual diseases. The choice of different tools would have effectively prevented a correct and unambiguous comparison of perceived HR - QoL in patients with equal diseases.

The analysis did not include socio-demographic factors and risk factors such as marital status, income, physical activity, smoking or alcohol consumption, which could affect the perceived level of HR-QoL. In subsequent studies, the authors will present the impact of various factors on the level of HR-QoL.

The study discusses the negative impact of the disease on mental health, but based on the analyses carried out, the opposite effect can be determined, namely the impact of mental health, whether positive, neutral or negative, on the course of the disease.

There are no restrictions that would prevent a reverse analysis from being carried out. The variables treated as attributes and forming the basis for decisions depend on the analyst. In this way, the same method can be configured to examine whether mental health (positive/neutral/negative) has an impact on treatment outcomes.

Furthermore, the authors plan to conduct a comprehensive, bidirectional analysis in the future. Authors are also developing a software tool that will facilitate the application of the presented method in different data sets and outcome definitions.

Conclusion

1) CD, CVD and NS (with the exception of the RE sphere) were among the group of diseases that most severely lowered HR - QoL in the individual spheres of the SF-36 in the group of patients under 65 years of age.
2) Among patients 65 and older, the group of diseases lowering HR - QoL was much more numerous: CD, CVD, NS, DM, DS, DSD-C, DSD-Th and depended on the individual spheres of quality of life assessed in the SF-36.
3) Disease group: DSD-C, DM, DS decreased HR - QoL of the older group of patients in the spheres: PF, RP, BP, GH, VT, SF, RE.
4) Diseases: RS and TD decreased HR - QoL to the least extent in older patients in spheres RP and SF. In the other spheres, they were also not among the main disease entities strongly reducing HR – QoL.
5) Creating common strategies for disease groups with similar outcomes and impact on HR - QoL will allow more efficient use of financial and organizational resources of the health care system. These activities can be directed at optimizing resources in public health activities and targeted targeting of relief efforts to specific patient groups.
6) Analysis of individual spheres will allow the implementation of targeted measures to improve HR - QoL of patients with various disease entities.

Ethical Approval

The authors confirm that all experimental protocols were approved by the Commission on Ethics of Scientific Research of the University of Information Technology and Management in Rzeszow (2/2022).

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Data Availability Statement

Data will be available from the corresponding author upon request.

Competing Interest declaration

The authors declare that they have no competing interests, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

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