Determinants of health-related quality of life in people with Parkinson's disease: A path analysis

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Abstract

Purpose: To identify the demographic factors, impairments and activity limitations that contribute to health-related quality of life (HRQOL) in people with idiopathic Parkinson's disease (PD).

Method: 210 individual with idiopathic PD who participated in the baseline assessment of a randomized clinical trial were included. The Parkinson's Disease Questionnaire-39 summary index (PDQ-39 SI) was used to quantify HRQOL. In order to provide greater clarity regarding the determinants of HRQOL, path analysis was used to explore the relationships between the various predictors in relation to the functioning and disability framework of the International Classification of Functioning (ICF) model.

Results: The two models of HRQOL that were examined in this study had a reasonable fit with the data. Activity limitations were found to be the strongest predictor of HRQOL. Limitations in performing self-care activities contributed the most to HRQOL in Model 1 ($\beta = 0.38$; $p<0.05$), while limitations in functional mobility had the largest contribution in Model 2 ($\beta = -0.31$; $p<0.0005$). Self-reported history of falls was also found to have a significant and direct relationship with HRQOL in both models (Model 1 $\beta = -0.11$; $p<0.05$; Model 2 $\beta = -0.21$; $p<0.05$).

Conclusions: Health-related quality of life in PD is associated with self-care limitations, mobility limitations, self-reported history of falls and disease duration. Understanding how these factors are inter-related may assist clinicians focus their assessments and develop strategies that aim to minimize the negative functional and social sequelae of this debilitating disease.

Keywords: Quality of life, Parkinson's disease, PDQ-39, Determinants, Path analysis

Abbreviations

ADL	Activities of daily living
AIC	Akaike Information Criteria
CFI	Comparative fit index
FOG-Q	Freezing of Gait Questionnaire
HRQOL	Health-related quality of life
HY	Hoehn and Yahr
ICD-9-CM	International Classification of Diseases, 9th Revision, Clinical Modification
ICF	International Classification of Functioning
MDRS	Modified Dyskinesia Rating Scale
MMSE	Mini-Mental State Examination
PD	Parkinson's disease
PDQ-39	Parkinson's Disease Questionnaire
PDQ-39 SI	Parkinson's Disease Questionnaire-39 Summary Index
RCT	Randomized controlled trial
RMSEA	Root mean square error of approximation
SCOPA	Scales for Outcomes in Parkinson's Disease
SEM	Structural equation modeling
SRMR	Standardized root mean square residual
TUGT	Timed "Up and Go Test"
UPDRS	Unified Parkinson's Disease Rating Scale

Introduction

Parkinson's disease (PD) is a chronic and progressive neurodegenerative condition with no known cure. The estimated prevalence of PD ranges from 125 to 550 in 100,000 people [1,2]. Its incidence increases with age, affecting approximately 1-2% of people over the age of 60 years and about 3-5% of those 80 years and older [1,3]. The variety of motor and non-motor symptoms associated with the disease may limit the ability of individuals to perform their daily activities and participate in life situations [4,5]. This may have a negative impact on their health-related quality of life (HRQOL), which takes into account aspects of their physical health, social function, emotional wellbeing and cognitive ability [6,7]. Health-related quality of life refers to the health dimension of quality of life, and is the dimension that is of most interest to clinicians because it provides an insight into how individuals perceive a disease, such as PD, to impact on their lives [8].

Despite an increase in the number of studies examining the HRQOL of people with PD, little is known about the factors that predict life quality. Most studies have used multiple regression analysis to identify the key predictors of HRQOL [9]. Although informative, multiple regression models do not take into account the potential complex inter-relationships between various predictor variables. Alternative statistical techniques such as path analysis provide greater insights, as they can identify the direct and indirect pathways through which the set of predictor variables influences the outcome variable [10]. For example, when the contribution of education, occupation and income on psychosocial health was examined using multiple regression analysis, higher educational level was not found to be predictive of good psychosocial health [11]. When potential causal relationships between the predictor variables (education, occupation and income) were considered using path analysis, however, the relationship between education and psychosocial health became clear. The contribution of education towards psychosocial health was found to be mediated by occupation and income [11]. This finding illustrates the theoretical importance of accounting for inter-relationships between predictor variables using path analysis.

Previous studies examining the predictors of HRQOL in PD have also not considered or conceptualized the pathways that link demographic factors, impairments, activity limitations and participation to life quality. Visser et al [12] illustrated the complex relationships between HRQOL, motor and non-motor impairments and the functional consequences of PD but did not consider the contribution of factors such as age, sex, disease duration and disease severity. This can make it difficult to draw conclusions about how demographic factors and various PD symptoms contribute to HRQOL.

The structural components and relationships proposed by the International Classification of Functioning, Disability and Health (ICF) [13] will be used in this study to explore the relationships between the determinants of HRQOL in people with PD. The ICF model was selected as a theoretical framework because it provides a standard and unified framework to describe the components of health and health-related domains for all peoples, including individuals with chronic disease [13]. The domains of the ICF are described from the perspective of the body, the individual and society according to body functions and structures, activities and participation [13]. The multi-perspective approach adopted by the ICF is a useful way to describe the complex relationships between the motor and non-motor symptoms of PD (Figure 1) [14,15]. The domains of the model also provide a framework to classify the potential predictors of HRQOL into clearly defined categories. This allows models to be developed in which HRQOL can be assumed to be dependent on personal and environmental factors, impairments in body structure or function and activity limitations (Figure 2) [13].

This study aims to identify the factors that contribute to HRQOL in people with PD and explore the direct and indirect relationships that exist between the identified variables using path analysis. The ICF framework will be analyzed and compared to an alternative exploratory model identified through causal search strategies. The two competing models will be examined in order to find the model of best fit that is consistent with a theoretical approach to HRQOL in PD.

Methods

Study design and participants

A cross-sectional analysis was conducted using data derived from an existing randomized controlled trial (RCT) [16]. Two hundred and ten individuals with idiopathic PD who undertook a baseline assessment for the RCT were included in this analysis. All participants had a diagnosis of idiopathic PD confirmed by a neurologist, were able to provide informed consent and were able to walk and safely participate in an exercise program [16]. Individuals below the threshold of cognitive decline, indicated by a Mini-Mental State Examination (MMSE) [17] score of less than 24 (age adjusted), were excluded to ensure that participants were able to provide informed consent and accurately report whether they had fallen in the last 12 months. Individuals with a disease severity of Stage 5 according to the modified Hoehn and Yahr (HY) [18] scale were also excluded as they were unable to complete the study protocol. The study was approved by The University of Melbourne Health Sciences Human Ethics Sub-Committee (HREC 0828579.3).

Outcome measures

Health-related quality of life

The Parkinson's Disease Questionnaire-39 (PDQ-39) [19] was used to assess HRQOL because it is a widely-used disease-specific instrument and is a recommended tool for measuring HRQOL in this population [9,20]. The summary score computed for the total scale (PDQ-39 SI) was used to provide an indication of overall HRQOL. The PDQ-39 SI has been shown to provide a valid and reliable indication of the overall impact of PD on functioning and wellbeing [21].

Personal and environmental factors

Personal factors examined included demographic characteristics such as age, sex, disease severity, disease duration, co-morbidities and self-reported history of falls (Figure 2). Disease severity and disease duration were categorized as personal factors because these variables describe the natural course of PD and contribute to

the extent of the impairment in body structures and function, activity limitations and participation restrictions. Disease severity was measured using the modified HY scale, which is a widely used instrument that describes the progression of disease [18]. Given the ordinal nature of this scale, participants were considered to have mild disease severity if they had a modified HY stage of 2 or less and moderate disease severity if they were rated as Stages 2.5, 3 or 4 [22].

Participants reported the absence or presence of co-morbid health conditions using a standard questionnaire. Co-morbid conditions were coded using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) [23]. Participants were also asked to report if they had any falls in the last 12 months. Social support was defined as whether participants lived alone or with others. Participants were categorized as having adequate social support if they were living with other people. This included individuals living in supported residential facilities.

Impairments in body structure or function

The motor component (Part III) of the Unified Parkinson's Disease Rating Scale (UPDRS) was used to quantify the severity of impairments in motor function in this sample [24]. The UPDRS-III has been used extensively in clinical and research settings to detail the motor impairments associated with PD [25,26]. The more affected side was assessed during the motor examination to avoid data redundancy [27]. The maximum score for this section is 56, with higher scores indicating greater symptom severity. The UPDRS-III was also divided into four subscales (bradykinesia or hypokinesia, tremor, rigidity, and postural instability and gait disorders) to gain further insight into how individual motor symptoms contribute to HRQOL [28].

Impairments in mental function and memory were assessed using UPDRS-I, while other motor and non-motor impairments such as dyskinesia, dystonia, clinical fluctuations and sleep disturbances were examined using UPDRS-IV [24]. Both these sections have high internal consistency and good inter and intra-rater reliability [27,29]. The Modified Dyskinesia Rating Scale (MDRS), which has

been shown to have good clinical utility and reliability, was also included as an additional measure of dyskinesia [30]. In order to measure the severity of freezing episodes, the Freezing of Gait Questionnaire (FOG-Q) was used [31]. This is a patient-reported scale with good validity and reliability [31,32].

Activity limitations

As shown in Figure 2, limitations in performing self-care activities and mobility were examined in relation to HRQOL. Self-care activities refer to the performance of daily tasks such as dressing and washing and were evaluated using the activities of daily living (ADL) component of the UPDRS (Part II). The scale ranges from 0-16, with a higher score indicating greater disability [24]. Mobility limitations include difficulties with the performance of transfers and walking such as rising from a chair, turning and walking in public places [33]. The Timed "Up and Go" test (TUGT) [34] was used to quantify mobility limitations as it has been shown to be a reliable and sensitive measure of functional mobility in people with PD [35].

Procedures

Participants were interviewed and examined by trained assessors once informed consent was obtained. Structured face-to-face interviews were used to standardize the collection of demographic details such as age, disease duration and the presence of co-morbidities. The clinical examination involved assessment of PD severity and disability using the UPDRS, modified HY scale and MDRS. Gait function was measured using the TUGT. The trained assessors also administered the FOG-Q and PDQ-39 during the session to standardize the way in which the questionnaires were completed.

Statistical analysis

Descriptive statistics were obtained for each predictor variable based on the ICF framework [13,33] shown in Figure 2. Path analysis was used to estimate and quantify the hypothesized causal relationships between demographic factors, PD

impairments, activity limitations and HRQOL. As illustrated in Figure 2, these relationships were assumed to be unidirectional and the error terms were not correlated based on prior knowledge from the literature [36,37]. A preliminary examination of the assumptions of path analysis led to a powered transformation of the predictor variables to reduce skewness and improve the normality and linearity of the residuals. Square root transformations were applied to disease duration and the PDQ-39 SI, UPDRS-I, UPDRS-II and UPDRS-IV scores, whilst an inverse transformation was applied to the time taken to complete the TUGT.

Structural equation modeling (SEM) was used to evaluate the fit of the final model by examining a number of statistics. To examine the magnitude of the discrepancy between the sample and fitted covariance matrices, the χ^2 statistic was used where a non-significant test indicates that the model and data were consistent [10]. Three additional measures of fit were also used to evaluate the model because the χ^2 test is sensitive to the number of variables included in a model and the sample size available [10]. The root mean square error of approximation (RMSEA) assess the approximate fit of the model, with values less than 0.05 indicating a reasonable goodness-of-fit. An advantage of the RMSEA is that confidence intervals can be calculated around the RMSEA value [10]. The comparative fit index (CFI) examines the difference between the overall fit of the two models; values greater than 0.95 suggest a good model fit, while the standardized root mean square residual (SRMR) is a descriptive fit statistic in which values below 0.08 indicate a good model fit [38,39]. It is important to note, however, that approximate fit indices such as the CFI, RMSEA and SRMR may be limited as measures of fit of a single model as they may be affected by large model misspecification [40].

The Tetrad program [41] was also used to search for causal relations between the predictor variables and find an alternative model of HRQOL in people with PD [42]. The Heuristic Best Significant Model Search (HBSMS) algorithm was used to find an alternative model of HRQOL. The HBSMS algorithm is a causal discovery algorithm that finds the best-fitting model by adding, reversing and deleting pathways of an 'empty' graph and examining the global χ^2 each time a change is made to the model [43]. PASW v17.0 (PASW Inc, Chicago, Illinois,

2009), AMOS 18.0 (Small Waters Corporation, 2009) and Tetrad IV (Tetrad project, 2012) were used to perform the statistical analyses required for this study.

Results

Participant characteristics

Table 1 outlines the participant characteristics. The sample consisted predominantly of men (67%) with a mean age of 67.9 years (SD 9.6) and a mean PD duration of 6.7 years (SD 5.6). Participants had mild to moderate impairments in motor function with UPDRS-III scores ranging from 3-33 and UPDRS-IV scores ranging from 0-14. They also had mild memory, mood and behavioural impairments (UPDRS-I range 0-8). About 51% of participants experienced freezing episodes. Chorea was the most frequent form of dyskinesia that was present (25%) and was also the most disabling form of dyskinesia (21%).

Relationship between HRQOL, personal and environmental factors

A path analysis model based on the ICF framework (Model 1) was developed to examine the relationship between personal and environmental factors, PD impairments and activity limitations with HRQOL. This model explained 54% of the variance in HRQOL and showed that self-reported history of falls was the only personal factor that contributed directly to HRQOL (β=-0.11; p<0.05) (Figure 3a). Disease duration and disease severity did not have a significant direct relationship with HRQOL. However, disease duration indirectly contributed to HRQOL through impairments in motor and non-motor function (β=0.21; p<0.005), mental impairments (β=0.18; p<0.05), and self-care limitations (β=0.22; p<0.0005). Similarly, disease severity was indirectly related to HRQOL via motor impairments (β=0.49; p<0.0005) and self-care limitations (β=0.12; p<0.05).

Relationship between HRQOL, PD impairments and activity limitations

The relationship between PD impairments, activity limitations and HRQOL was further examined in Model 1 (Figure 3b). In this model, limitations in performing activities of daily living (ADL) and functional mobility were the strongest

contributing factors of HRQOL. Self-care (β=0.38; p<0.0005) and mobility limitations (β=-0.14; p<0.05) had significant and direct relationships with HRQOL. Mental impairments (UPDRS-I) and impairments in motor and non-motor function (UPDRS-IV) were also significant contributing factors. The contribution of mental impairments was established both through a direct relationship with HRQOL (β=0.30; p<0.0005) and indirectly via self-care limitations (β=0.16; p<0.05). Likewise, impairments in motor and non-motor function contributed both directly to HRQOL (β=0.19; p<0.005) and indirectly through self-care limitations (β=0.10; p<0.05). The standardised direct, indirect and total contributions of the personal and environmental factors, PD impairments and activity limitations on HRQOL are shown in Table 2.

A model of HRQOL in people with PD

The overall fit of Model 1 was assessed using a number of fit statistics. As shown in Table 3, the SRMR value (0.04) was less than 0.08 indicating that this model was a good fit to the data. This was supported by a CFI value of greater than 0.95. In contrast, the χ^2 test of absolute fit was significant (p<0.001) and the RMSEA value was greater than 0.1, suggesting that the model and data were not consistent. It must be noted, however, that the χ^2 test may be sensitive to the sample size available and the underlying distribution of the various predictor variables examined in the model [38]. Similarly, the RMSEA index may be misleading when the degrees of freedom (*df*) and sample size are small [44,38].

Given the conflicting results obtained from the different fit statistics, an alternative model of HRQOL (Model 2) in people with PD was examined (Figure 4). Model 2 was obtained using the HBSMS algorithm in the Tetrad program, and it explained 27% of the variance in HRQOL. In contrast to Model 1, limitations in functional mobility (β=-0.31; p<0.05) was the strongest predictor while self-care limitations did not contribute directly or indirectly to HRQOL. Disease duration also had a significant and direct relationship with HRQOL (β=0.27; p<0.05). Other significant contributing factors in this model were self-reported history of falls, age, disease severity, mental impairments and impairments in motor function. Self-reported history of falls contributed directly to HRQOL (β=-

0.21; $p<0.05$) and indirectly via disease duration (β=-0.16; $p<0.05$) and disease severity (β=-0.20; $p<0.05$). Age also had a direct (β=-0.15; $p<0.05$) and indirect relationship with HRQOL through mobility limitations (β=-0.25; $p<0.05$) and disease duration (β=-0.25; $p<0.05$). Disease severity, impairments in motor function and mental impairments, however, did not contribute directly to HRQOL. The contribution of these factors was mediated by mobility limitations and disease duration, which was similar to the findings obtained from Model 1.

The overall fit of Model 2 was examined with the same fit statistics used to evaluate Model 1. The results indicate that Model 2 provides a reasonable explanation of the relationship between demographic factors, PD impairments, activity limitations and HRQOL (Table 3). The χ^2 test of absolute fit was not significant ($p=0.062$), indicating that this model was a good fit to the data. This was further supported by an RMSEA value that was less than 0.05 (90% CI 0.00, 0.06), an SRMR value that was less than 0.08 and a CFI value that was greater than 0.95. Model 2 also had a smaller Akaike Information Criteria (AIC) value (145.7), which suggests that this simpler model may provide a better explanation of the relationship between HRQOL and demographic factors, PD impairments and activity limitations.

Discussion

The models of HROQL that were examined in this study had a reasonable fit with the data, indicating that it is possible to identify the key determinants of HRQOL in individuals with idiopathic PD using path analysis. The model coefficients and pathways showed that a complex interaction between limitations in self-care activities and functional mobility, impairments in motor and mental function and personal factors such as disease duration and disease severity explained 54% (Model 1) and 27% (Model 2) of the variance in HRQOL in people with PD. Whilst the models identified strong associations between HRQOL and demographic factors, PD impairments and activity limitations, the findings of this study need to be interpreted with caution as the direction of the relationships between the variables was selected based on previous literature [36,37].

The theoretically-based model of HRQOL (Model 1) that was examined provided a reasonable explanation of the HRQOL of people with PD, even though the χ^2 test and RMSEA index suggested that the model and the data were not consistent. One of the strengths of this model is that it was based on the ICF framework. It takes into account the complexity of PD and uses a psychosocial and pathophysiological basis to describe the determinants of PD [13]. In contrast, the automated search routine in Tetrad returned an exact-fitting model of HRQOL (Model 2) that had a good fit with the data. This model, however, was derived primarily from this particular sample of PD participants and therefore may not reflect the HRQOL of the broader population of people with PD [10]. Given these findings with limited data from a single sample, there is a need to validate the findings of this study. In particular, it may be worth testing Model 2 on other PD population samples to verify the conclusions arising from the current sample.

In this sample of people with PD, self-reported history of falls was identified as a significant predictor of HRQOL in both models. It contributed both directly to HRQOL as well as indirectly through other factors such as self-care limitations, disease duration and disease severity. This suggests that participants who had a fall in the last 12 months were more likely to experience poor life quality. This is in agreement with previous literature that has shown falls to be negatively associated with HRQOL [45,46]. Nevertheless, further prospective research is warranted to investigate the relationship between people with PD who fall and their HRQOL. Specifically, it may be useful to examine whether the number of falls predicts HRQOL or whether injurious falls and/or fall-related injuries are a better predictor of HRQOL in people with PD.

Activity limitations were also a stronger predictor of HRQOL than impairments in body structure or function. In Model 1, limitations in performing self-care activities as measured by the UPDRS-II had the largest contribution, explaining 38% of the variance. In Model 2, however it was limitations in functional mobility that were identified as the strongest predictor of HRQOL, explaining 31% of the variance. These findings replicate previous literature that shows that people with greater disease disability and/or who experience difficulties with balance and walking were more likely to have poor HRQOL [46-49]. It also

corroborates findings by Ellis et al [49] who found that mobility limitations were stronger predictors of HRQOL than motor impairments. Thus, in order to optimize the HRQOL of people with PD, there is a need to take into consideration their ability to perform daily activities, particularly those activities limited by mobility.

Impairments in motor function did not contribute directly to HRQOL in people with PD in either models. The contribution of motor symptoms was mediated through other factors, which included limitations in functional mobility and self-care activities. This was in agreement with Visser et al [12] who found that motor symptoms, in particular axial symptoms had an indirect relationship with HRQOL. Similarly, the finding that memory, mood and behavioural impairments predicted HRQOL was consistent with previous literature. Non-motor symptoms such as depression, anxiety and hallucinations have been shown to be strong predictors of HRQOL [9,48].

The results of this analysis also suggest that the contribution of disease severity may be mediated by other factors. When other predictor variables were included in the structural model, disease severity did not contribute directly to HROQL. Instead, it contributed indirectly to HRQOL through other factors including motor and mental impairments, disease duration, mobility limitations and self-care limitations. These findings highlight the benefit of using path analysis to examine the complex way in which PD impairments, personal factors and activity limitations inter-relate with HRQOL.

A limitation of this study was that participants were residents of metropolitan Melbourne with mild to moderate disease and reasonable cognition. As individuals with advanced disease (HY Stage 5) were not included in the sample, these findings may not necessarily be generalized to this subgroup. Similarly, the generalizability of findings to people with PD with cognitive impairment may be limited. Further work is required to investigate the factors that predict HRQOL in a broader sample of people with PD. Quality of life is also a complex multi-dimensional concept which encompasses all aspects of life including health, socio-economic status, global issues, social relationships and personal

characteristics [50]. Consequently, the limitations associated with focusing only on HRQOL need to be considered when interpreting the findings from this research to overall life satisfaction.

A further limitation was that definitive causal inferences cannot necessarily be drawn from the results because the sample size was small relative to the number of model parameters that were included and the models examined were largely exploratory in nature [51]. Powered transformations were also applied to the predictor variables making the model more difficult to interpret [52]. Thus, the conclusions that can be drawn about the relationship between the transformed variables and HRQOL have to be interpreted with caution. Potential moderating effects between the predictor variables were also not examined in the path model. Further investigations examining the mediation and moderation effects among the determinants of HRQOL using larger sample sizes are therefore required in order to develop a better understanding of how people with PD perceive their life quality.

This study has shown that factors such as limitations in performing self-care activities and functional mobility, self-reported history of falls and disease duration may contribute directly to the HRQOL of people with PD. It also demonstrated that a model that includes personal and environmental factors, PD-specific impairments and activity limitations can be used to characterize the HRQOL of people with PD. Understanding the inter-relationships between these factors may assist clinicians to focus their assessments and clinical decision-making processes.

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Table 1 Descriptive summary of participant characteristics (*n*=210)

Characteristic	*n* (%)	Mean (SD)
Age [yrs]		67.9 (9.6)
PD duration [yrs]		6.7 (5.6)
History of falls	116 (55)	
Sex Males	140 (67)	
Females	70 (33)	
Modified HY stage		2.5 (1.0)[§]
Mild severity (HY stages ≤2)	90 (43)	
Moderate severity (HY stages ≥2.5)	120 (57)	
Social support		

Lives alone	38 (18)	
Lives with others	172 (82)	
Presence of co-morbidities	207 (99)	
Neoplasms	48 (23)	
Diseases of the CNS and sense organs	149 (71)	
Endocrine, nutritional and metabolic disorders	18 (9)	
Circulatory disorders	134 (64)	
Digestive disorders	46 (22)	
Genitourinary disorders	62 (30)	
Diseases of the musculoskeletal system	101 (48)	
Symptoms, signs and ill-defined conditions	193 (92)	
UPDRS		
Part I (Mentation and memory)		2.6 (1.8)
Part II (ADL)		11.5 (5.9)
Part III (Motor)		15.2 (6.1)
Bradykinesia		8.4 (3.6)
Tremor		1.3 (1.3)
Rigidity		1.2 (0.8)
Postural instability and gait disorders		3.3 (2.1)
Part IV (Motor and non-motor function)		3.0 (2.7)
FOG-Q		
Freezing severity		5.9 (5.4)
Freezing episodes (item 3)	107 (51)	
MDRS		0.4 (0.8)
TUGT [secs]		11.7 (8.2)
PDQ-39 SI		20.9 (12.7)

SD, Standard deviation; Modified HY stage, Modified Hoehn and Yahr stage; CNS, Central Nervous system; UPDRS, Unified Parkinson's Disease Rating Scale; ADL, Activities of daily living; FOG-Q, Freezing of Gait Questionnaire; MDRS, Modified Dyskinesia Rating Scale; TUGT, Timed Up and Go Test; PDQ-39 SI, Parkinson's Disease Questionnaire-39 summary index

[§]Median (IQR)

Table 2 Standardised direct, indirect and total relationship of personal and environmental factors on HRQOL

Variable	Direct relation	Indirect relation	Total relation
Personal factors			
Age	-0.04	-0.04	-0.08
Sex	-0.02	-0.04	-0.06
Disease duration	0.04	0.22	0.26
Disease severity (modified HY scale)	-0.02	0.17	0.15
Co-morbidities	-0.01	-0.00	-0.01
Falls history	-0.11	-0.12	-0.23
Environmental factor			
Social support	0.02	0.03	0.05
Impairments			
Motor function (UPDRS-III)	-0.03	0.24	0.21
Motor and non-motor function (UPDRS-IV)	0.20	0.05	0.25
Mental function (UPDRS-I)	0.30	0.07	0.37
Activity limitations			
Mobility (TUGT)	-0.14	-0.03	-0.17
Self-care (UPDRS-II)	0.38	-	0.38

Modified HY scale, Modified Hoehn and Yahr scale; UPDRS, Unified Parkinson's Disease Rating Scale; PIGD, Postural instability and gait disturbance; FOG-Q, Freezing of Gait Questionnaire; MDRS, Modified Dyskinesia Rating Scale; TUGT, Timed Up and Go Test

Table 3 Summary of final model fit statistics

Model fit index	Value
Model 1	
χ^2 test	27.65
df	3

p	<0.001
CFI	0.96
RMSEA	0.20
90% CI	0.14, 0.27
SRMR	0.04
AIC	229.7
Model 2	
χ^2 test	69.69
df	53
p	0.062
CFI	0.99
RMSEA	0.04
90% CI	0.00, 0.06
SRMR	0.05
AIC	145.7

χ^2 test, chi-square test; *df*, degrees of freedom; CFI, comparative fit index; RMSEA, root mean square error of approximation; CI, confidence interval; SRMR, standardised root mean square residual

Fig. 1 Examples of the interactions between the ICF components for people with PD [14, 15]. Adapted with permission from the World Health Organization [13].

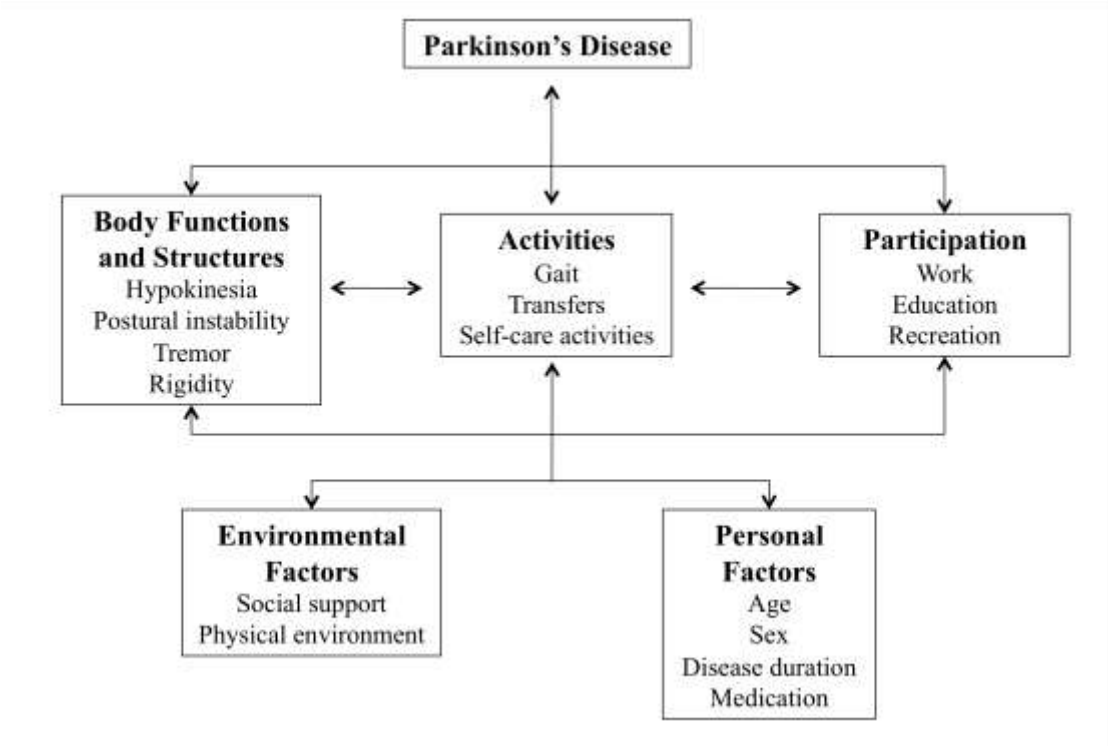


Fig. 2 Measurement model illustrating the relationship between demographic factors, PD impairments, activity limitations and HRQOL based on the ICF framework [13, 33]

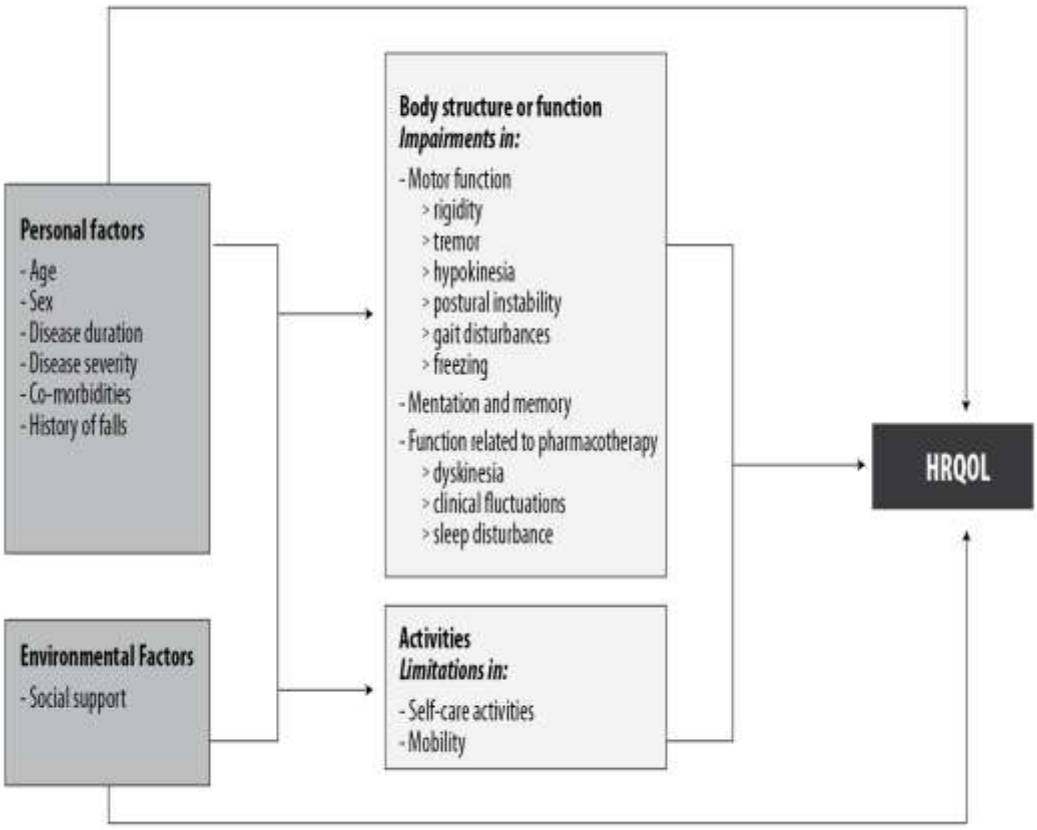
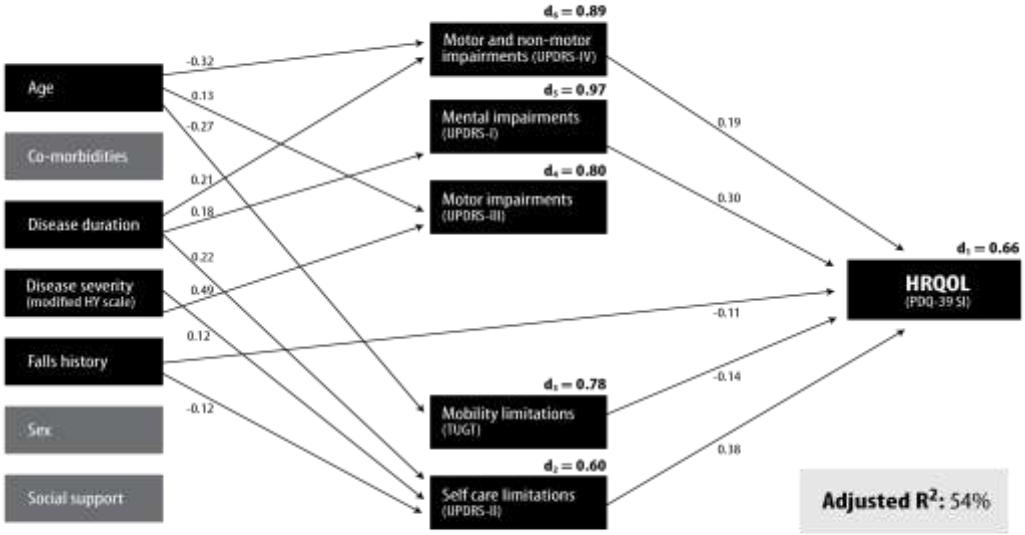


Fig. 3 Model of HRQOL illustrating the relationship between HRQOL and (a) personal and environmental factors; (b) PD impairments and activity limitations only. d_x represents the residual term which reflects the amount of unexplained variance and measurement error. All path coefficients are standardized. Non-significant path coefficients are not shown for reasons of readability.

(a)



(b)

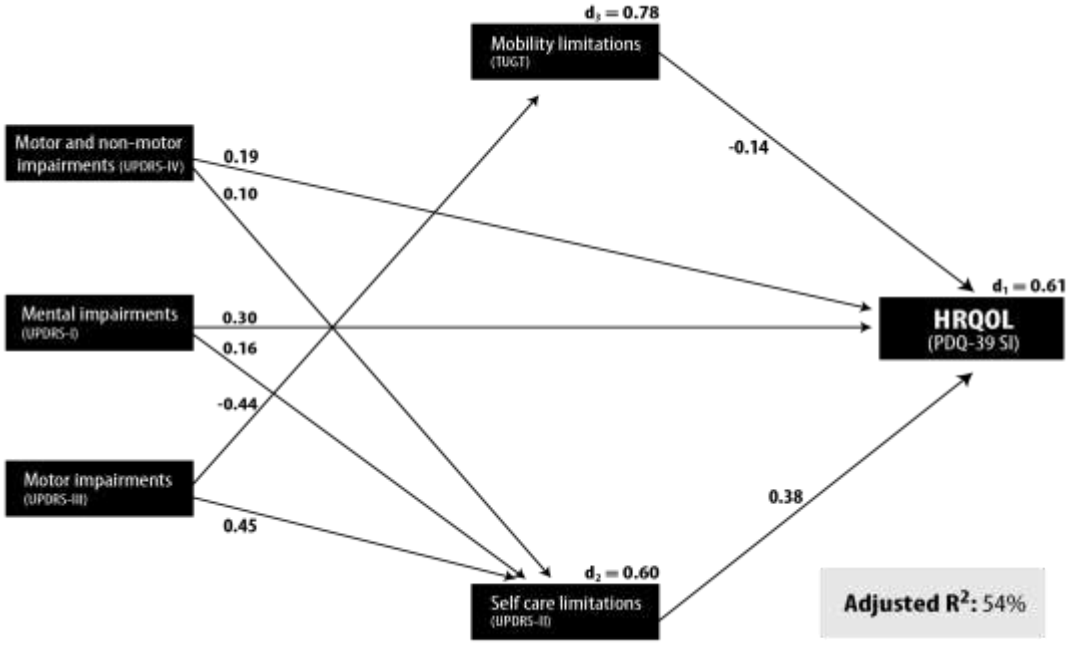
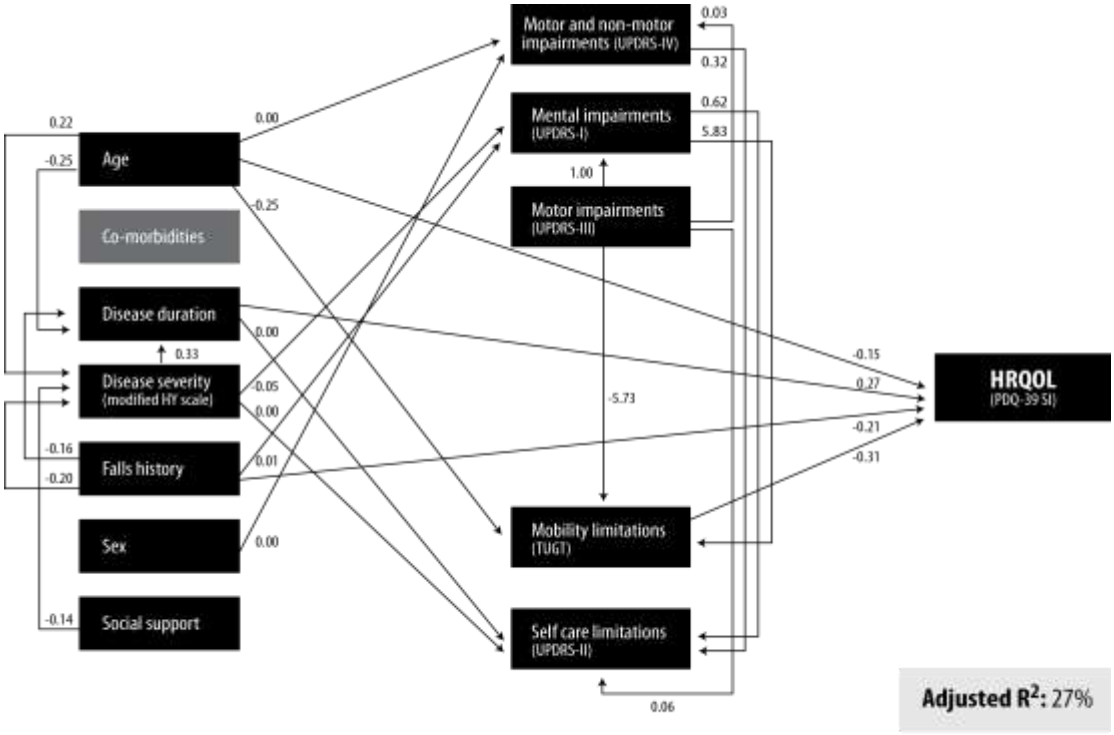


Fig. 4 Alternative model of HRQOL in people with PD obtained through causal search strategies. All path coefficients are standardized.


Motor and non-motor impairments (UPDRS-IV)
Mental impairments (UPDRS-I)
Motor impairments (UPDRS-III)
Mobility limitations (TUGT)
Self care limitations (UPDRS-II)
Age
Co-morbidities
Disease duration
Disease severity (modified HY scale)
Falls history
Sex
Social support
HRQOL (PDQ-39 SI)
0.03
0.32
0.62
5.83
1.00
0.22
-0.25
0.00
-0.25
0.00
0.33
0.05
0.00
0.01
0.00
-0.16
-0.20
-0.14
-0.15
0.27
-0.21
-0.31
-5.73
0.06
Adjusted R2: 27%