Diet, Physical Activity, and Stress Among Wheelchair Users with Multiple Sclerosis: Examining Individual and Co-Occurring Behavioral Risk Factors

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Abstract

Objective: This study examined individual and co-occurring behavioral risk factors (diet, exercise, and stress) in wheelchair users with multiple sclerosis (MS) and potential association with MS symptoms (i.e., fatigue, depression, anxiety, pain, sleep, and health-related quality of life [HRQOL]).

Design: Survey

Setting: General Community

Participants: One hundred twenty-three wheelchair users with MS completed this study.

Interventions: Not applicable

Main Outcome Measures: Participants were mailed instructions for accessing online questionnaires (demographic and clinical characteristics, Godin Leisure-Time Exercise Questionnaire, Perceived Stress Scale, Automated Self-Administered 24-Hour Dietary Assessment Tool, and MS symptoms).

Results: Standard cut-points were utilized to categorize behavioral risk factors and then identify the extent and distribution of these behaviors both individually and co-occurring. We then analyzed the associations between behavioral risk factors and MS symptoms using bivariate correlation analyses and Mann-Whitney U tests. The mean age of participants was 60.6±10.0 years, 76% identified as female, 82% had a progressive disease course, and the mean MS duration

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was 23.0±9.7 years. Seven participants were classified as having 0 negative health behaviors, 41 participants had 1 negative health behavior, 49 participants had 2 negative health behaviors, and 26 participants had 3 negative health behaviors. The number of negative health behaviors was significantly correlated with HRQOL (physical, r=.30; psychological, r=.47), sleep (r=.25), depressive symptoms (r=.36), and anxiety (r=.43). Mann-Whitney U tests indicated greater fatigue, depression, and anxiety as well as lower sleep quality and HRQOL among participants who reported 2 or 3 behavioral risk factors compared to 0 or 1 behavioral risk factor.

Conclusions: Future research should examine the design and implementation of multiple health behavior change interventions targeting co-occurring behavioral risk factors among wheelchair users with MS.

Keywords

multiple sclerosis; wheelchairs; health behaviors; quality of life; risk factors

There is increasing recognition of the benefits of health behaviors for promoting wellness among people living with multiple sclerosis (MS).[1] Indeed, the National MS Society (NMSS) convened a Wellness Working Group (WWG) that highlighted diet, exercise, and stress as critical health behaviors of interest for improving MS symptoms and disease progression.[1] To date, there is limited inquiry regarding behavioral risk factors (i.e., negative health behaviors) among wheelchair users with MS who may benefit most from second-line lifestyle therapies, yet mobility disability is a hallmark feature of MS with an estimated 32% of persons with MS using a wheelchair as a primary assistive device.[2]

Poor diet has been highlighted as the most common behavioral risk factor among persons with MS.[3] The existing, but limited cross-sectional research on diet has generally examined poly-unsaturated fat supplementation and vitamin D in persons with MS.[1] There has been one examination of diet quality among wheelchair users with MS that utilized the Healthy Eating Index-2015 as a measure of diet quality, and compared the degree to which diet aligned with key components of the Dietary Guidelines for Americans.[4] Results indicated some positive trends wherein Healthy Eating Index-2015 scores were predominately above the general population means; however, scores for dairy, total protein foods, seafood and plant protein were lower than the general population.[5] The NMSS WWG report identified no existing published randomized controlled trials (RCTs) of diet in persons with MS. Four RCTs have been published since that report;[6–9] however, these studies focused on individuals with mild-moderate MS disability. Diet quality in conjunction with other behavioral risk factors must be further examined cross-sectionally in order to inform future RCTs targeting overall health in this unique population of wheelchair users.

Insufficient exercise is another prevalent behavioral risk factor that is widely studied in persons with MS.[3] The NMSS WWG report identified exercise as a safe and effective second-line therapy or improving MS symptoms and possibly slowing disease progression.[1] The NMSS WWG highlighted a need for more research to develop guidelines and programs for wheelchair users who have more severe MS. Further research is key for guiding tailored physical activity interventions by identifying appropriate measurement tools and training modalities given most physical activity programs for persons with MS focus on walking

and step counts. Indeed, there is a stark lack of large-scale assessment of device-measured and self-reported free-living physical activity among wheelchair users with MS necessary to assess physical activity levels in this subpopulation. Appropriate assessment of lifestyle physical activity and structured exercise behavior independently and co-occurring with other behavioral risk factors is key for determining the soundest lifestyle approaches for improving health among wheelchair users with MS.

Additionally, the NMSS WWG placed a high value on stress, as persons with MS experience higher prevalence of depression, anxiety, pain, fatigue, and sleep problems than the general population.[1] Wheelchair users are particularly susceptible, as the compounding effects of severe MS can lead to mobility impairment and other physical and psychological symptoms. Stress management interventions demonstrate preliminary efficacy for improving emotional wellness and decreasing symptoms in persons with MS.[10] The NMSS WWG prioritized understanding of the role of stress in emotional health and/or the course of MS disease[1] – prior to initiating RCTs for stress management in wheelchair users with MS, the prevalence of stress must be examined cross-sectionally.

The current study focuses on individual and co-occurring behavioral risk factors that may be targeted in behavioral interventions among wheelchair users with MS. Such inquiry is essential given the high incidence of individual and co-occurring behavioral risk factors associated with comorbidities and neuroperformance markers in ambulatory persons with MS.[3,11] This study aims to address a gap in the literature, namely the paucity of research examining individual and co-occurring behavioral risk factors in wheelchair users with MS and potential association with MS symptoms (i.e., fatigue, depression, anxiety, pain, sleep, and health-related quality of life [HRQOL]).

Methods

Participants

Participants were recruited for a cross-sectional study that occurred between February 2020 and July 2021. The study recruitment flyer was distributed via e-mail by the NMSS, iConquerMS, and North American Research Committee on MS (NARCOMS) registry. The inclusion criteria were: (a) age 18 years or older, (b) diagnosis of MS, (c) use of a wheelchair for mobility 50% of the day, (d) Internet access, and (e) willingness to complete the study protocol.

Measures

Diet.—The Automated Self-Administered 24-Hour (ASA24) Dietary Assessment Tool (version 2018) was utilized for collection of online, automated 24-hour dietary recalls. The ASA24 uses a multi-pass method for reporting intake of all food and drinks consumed during the previous 24-hour period.[12] Participants were provided a unique username and password and prompted on 3 random, non-consecutive mornings to complete ASA24 dietary recalls. Dietary recalls were considered invalid if the overall intake was below 500 calories, and valid days were combined for each participant to yield an overall mean.[13] Health Eating Index-2015 (HEI-2015) scores were calculated using SAS (versions 9.4) code provided

by the National Cancer Institute.[14] The HEI-2015 includes 13 component scores based on common food groups or nutrients (i.e., total fruits, whole fruits, total vegetables, green and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, added sugars, and saturated fat). The minimum score for each component is 0 and a maximum score of 5 or 10, depending on the component, where higher total scores reflect better diet quality. Cutoff scores were applied for each participant to assess presence of poor diet, specifically below the age-specific population average on the HEI-2015 58.[15]

Physical Activity.—The Godin Leisure-Time Exercise Questionnaire (GLTEQ) was used to measure physical activity bouts during the previous 7-day period lasting at least 15 minutes.[16] Participants reported the number of days they engaged in light, moderate, and strenuous activity. The GLTEQ was deemed appropriate given wheelchair users with MS can engage in a variety of light, moderate, and strenuous activities as they often have some lower body functioning. Scores were converted to Health Contribution Scores (GLTEQ HCS) by multiplying strenuous and moderate days by 9 and 5, respectively with scores ranging from 0–98.[17] GLTEQ HCS cutoff score of <14 was used to classify participants as insufficiently active.[17] The GLTEQ is the most widely used self-report measure of leisure time exercise among persons with MS across a wide range of disability levels with strong test-retest reliability indicated by an intra-class correlation coefficient (ICC) of 0.74.[18]

Stress.—The 10-item Perceived Stress Scale (PSS) was used to measure stress.[19] Items are rated on a Likert scale from 0 (never) to 4 (very often). Item scores are summed to yield a total score ranging from 0–40 with higher scores indicating greater stress. Cutoff scores were applied to identify participants with high prevalence of perceived stress of PSS 27.[20] The PSS has been widely used as a valid measure among persons with MS, and 10-item PSS has demonstrated better psychometric value than the 14-item version ($\alpha = 0.91$).[20]

Symptoms.—The 9-item Fatigue Severity Scale (FSS) was used to measure the severity and impact of fatigue.[21] Each item is rated on a 7-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree) and total score calculated as the mean (i.e., range 0–7). Reliability of the FSS in persons with MS is well established (ICC = 0.75).[22] The Hospital Anxiety and Depression Scale (HADS) was used to assess symptoms of anxiety and depression.[23] The HADS includes 7 items regarding anxiety and 7 items regarding depression. Items are rated on Likert scales ranging from 0–3 Items for each HADS subscale and are summed to yield anxiety and depression scores ranging from 0–21 where higher scores indicate greater symptoms. Reliability of the HADS in persons with MS is well established (ICC = 0.83).[24] Pain was measured using the Short-form McGill Pain Questionnaire (MPQ).[25] Fifteen items are presented regarding sensory and affective components of pain rated on a scale of 0 (none) to 3 (severe). MPQ items are summed to yield a total score ranging from 0–45 where higher scores indicate greater pain. The MPQ has good evidence for its reliability and validity as a measure of pain and been used in many studies among persons with MS.[25,26] The Pittsburg Sleep Quality Index (PSQI) was used to measure sleep quality. The PSQI includes 19 items that measure 7 components regarding the quality of one's sleep and sleep disturbances over the past

month.[27] Components were scored from 0 (fairly good) to 3 (very bad) to yield a global score ranging from 0 to 21 where higher scores reflect worse sleep quality. The PSQI has demonstrated strong reliability in a recent validation study ($\alpha = 0.83$).[28] HRQOL was measured using the 29-item Multiple Sclerosis Impact Scale (MSIS-29).[29] The MSIS-29 includes two domains: physical (20 items) and psychological (9 items) with items rated on a 5-point Likert scale from 1 (not at all) to 5 (extremely). Each domain's subscale is calculated to yield a score from 0–100 where higher scores represent greater impact of MS. The MSIS-29 has demonstrated strong reliability for physical and psychological subscales ($\alpha = 0.89$–0.96).[30]

Demographics and MS Clinical Characteristics.—Participants self-reported their age, sex, marital status, employment status, race/ethnicity, education, MS clinical type, and MS disease duration. Disability status was measured using the single-item Patient Determined Disease Steps (PDDS) with scores ranging from 0 (normal) to 8 (bedridden).[31]

Procedures

Ethical considerations and study procedures were approved by the University of Alabama at Birmingham Institutional Review Board. Interested participants contacted the research team and completed a telephone screening to assess eligibility. Eligible participants were then contacted by the research team via phone to confirm it was an appropriate time to send the study package in the weeks following screening (i.e., packets were sent in groups, not individually after each screening call). The study packets that were mailed to each participant included two copies of the informed consent document and instructions for completing the study protocol. The consent form outlined considerations and precautions regarding confidentiality and privacy. Upon confirmation of receipt of the study package, individual links and prompts to complete all questionnaires were delivered via e-mail as well as optional text messages if participants preferred prompts via mobile phone. The battery of questionnaires was administered using Qualtrics including measures of Demographic and MS Clinical Characteristics, Physical Activity, Stress, and Symptoms and participants could complete the survey at any time during the 7-day data collection period. The ASA24 protocol aligned with standard practice wherein participants were prompted during the 7-day data collection period on three random, non-consecutive days to complete a 24-hour dietary recall using the ASA24 website. Participants were only considered enrolled if they returned a signed informed consent document and received remuneration for their time completing the 7-day study protocol.

Statistical Analyses

Primary data analyses were conducted using IBM SPSS Statistics for Windows, version 28 (IBM Corp., Armonk, NY, USA). Descriptive statistics were utilized for summarizing the sample demographic and MS clinical characteristics, HEI-2015 total scores generated using ASA24 data, GLTEQ HCS, PSS, and questionnaires regarding symptoms. Data were checked for normality using Shapiro–Wilks tests. The percentage of participants reporting each individual behavioral risk factor and percentage of participants reporting 0, 1, 2, or 3 behavioral risk factors was calculated. Pearson's and Spearman's correlation analyses were used to examine the associations between number of behavioral risk factors and symptoms.

Correlation coefficient values of 0.1–0.29 were interpreted as small, 0.3–0.49 as moderate, and 0.5 and above as large.[32] Symptoms identified as significant correlates with number of behavioral risk factors were then assessed for individual contributions using Mann-Whitney U tests comparing participants reporting 0 or 1 risk factor (i.e., group 1) to participants reporting 2 or 3 risk factors (i.e., group 2).

Results

Participants

Demographic and clinical characteristics for the 123 participants are presented in Table 1. The mean age among participants was 60 years, time since MS diagnosis was 23 years, and median(IQR) PDDS was 7(0). Eighty-two percent reported progressive disease course, and 50% used a power wheelchair as their primary assistive device. The majority of participants were female (75%), married (61%), Caucasian (85%), and had a college degree or more (71%).

Behavioral Risk Factors and Symptoms

Mean values for behavioral risk factors (i.e., HEI-2015, GLTEQ HCS, and PSS) and symptoms are presented in Table 2. The prevalence and patterns of behavioral risk factors above aforementioned cutoff values are presented in Table 3. The most common combination of behavioral risk factors was insufficient physical activity alone (28%), followed by insufficient physical activity and high stress (22%) and all 3 behavioral risk factors (21%). Additionally, Supplemental Table 1 provides the prevalence of each behavioral risk factor by demographic variables. For example, insufficient physical activity was reported by 90% or more in the following subgroups: Single/Divorced/Widowed, Other race, and Power wheelchair users.

Bivariate Correlations

Results from the Spearman and Pearson Bivariate correlation analyses examining associations between number of behavioral risk factors and symptoms are presented in Table 4. Significant moderate correlations were noted for depression (r=.36), anxiety (r=.43), physical HRQOL (r=.30), and psychological HRQOL (r=.47). A significant correlation of small magnitude was noted between number of behavioral risk factors and sleep quality (r=.25) and fatigue (r= .24).

Mann-Whitney U Test

Mann-Whitney U Test was used to compare participants who reported 0 or 1 behavioral risk factor to participants who reported 2 or 3 risk factors regarding the significant symptoms identified in the bivariate correlation analyses. Results indicated that depression, anxiety, sleep quality, physical HRQOL and psychological HRQOL were worse among participants with 2 or 3 behavioral risk factors (Table 5).

Discussion

The current study is the first focal examination of individual and co-occurring behavioral risk factors among wheelchair users with MS. The most common combination of behavioral risk factors in this sample was insufficient physical activity, followed by the combination of insufficient physical activity and high stress and all 3 behavioral risk factors. The symptoms significantly associated with reporting 2 or 3 behavioral risk factors were fatigue, depression, anxiety, sleep quality, physical HRQOL, and psychological HRQOL. Collectively, it is clear that there is a high prevalence of behavioral health risk factors among wheelchair users with MS and participants with the most risk factors reported worse symptoms.

This study builds upon existing literature examining individual and co-occurring symptoms in persons with mild-moderate MS. This literature highlights diet as the most common behavioral risk factor and the most prevalent combination of risk factors was poor diet and insufficient physical activity.[3] Importantly, the combination of poor diet and insufficient physical activity was associated with number of comorbidities and neuroperformance markers.[11] Findings from the current study highlight physical activity as the most common behavioral risk factor among wheelchair users with MS, which align with a recent publication examining perceptions of the NMSS physical activity guidelines among this sample wherein 58% of participants reported not meeting the physical activity guidelines and 30% only sometimes meeting the physical activity guidelines (i.e., low levels of physical activity).[33] Collectively, this bolsters the need for targeted physical activity guidelines and programs given the distinctive needs of persons with MS who use a wheelchair as their primary mobility device to assist in the clinical management of symptoms and disease progression. Additionally, stress was not examined as a behavioral risk factor in the previous studies, but the need for consideration highlighted by the NMSS WWG is evidenced by the prevalence of high stress among this sample (i.e., 49% reporting high stress).

The best practice for addressing behavioral risk factors is behavioral health promotion interventions. There are currently no widely available physical activity, stress management, or diet interventions for wheelchair users with MS. The first physical activity guidelines that include wheelchair users with MS were published in 2020[34] and researchers are currently creating and pilot testing adapted exercise programs tailored to the unique needs of this population.[35] The results from this study indicate that there may be substantial benefit for including stress management and diet in a behavioral intervention aiming to increase physical activity among wheelchair users with MS. Previous literature indicates substantial benefits of physical activity on the fatigue, depression, anxiety, sleep quality, and HRQOL that may be further improved by incorporating diet and stress management as appropriate.[36, 37] There is still substantial inquiry and evidence needed to prescribe best practices in the promotion of multiple health behaviors in behavioral interventions, however the overall benefits are established.[38, 39] Therefore, clinicians may consider discussion of behavioral risk factors along with strategies for improving overall health during interactions with patients.

Study Limitations

We acknowledge several limitations in the current study. First, the cross-sectional design limits the ability to determine causality or directionality but provides a foundation regarding associations for guiding further innovative research. Given the lack of validated cut points for commonly applied device measures of physical activity such as accelerometry, a self-reported measure was used in this study. We assert that previous evidence suggests weak support for positive self-report bias when measuring physical activity and 87% of this sample reported insufficient levels of physical activity.[40] However, we highlight the potential need for validating adaptations of the GLTEQ that include wheelchair-specific examples of physical activity. The generalizability of these results may be limited based on the need for Internet access and technological skills for completing online dietary recalls as well as cognitive functioning, which was not assessed in the current study. Additionally, this study was completed at the height of the COVID-19 pandemic which may have impacted engagement in health behaviors, but provides meaningful benchmarks regarding the current status of behavioral risk factors among wheelchair users with MS.

Conclusion

The present study provides preliminary evidence regarding individual and co-occurring behavioral risk factors among wheelchair users with MS. Results indicate that the majority of wheelchair users with MS are not meeting physical activity guidelines and 20% are (i) insufficiently physically active, (ii) report poor diet, and (iii) high stress (i.e., all 3 behavioral risk factors). Greater fatigue, depression, and anxiety as well as lower sleep quality and HRQOL were present among participants who reported 2 or 3 behavioral risk factors. Future research should examine the design and implementation of multiple health behavior change interventions targeting co-occurring behavioral risk factors among wheelchair users with MS.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Funding:

Conflict of Interest:

This research was funded in part, by a pilot grant program supported by the Consortium for Multiple Sclerosis Centers and EMD Serono Inc. awarded to Dr. Silveira. Dr. Cutter reports personal fees from Pythagoras Board membership, personal fees from Brainstorm Cell Therapeutics, personal fees from Teva Neuroscience, personal fees from EMD Serono, personal fees from Novartis, personal fees from CSL Behring, personal fees from Avexis Pharmaceuticals, personal fees from Genzyme, personal fees from Medimmune/Viela Bio, personal fees from Receptos/celgene, personal fees from Biolinerx, personal fees from Sanofi-Aventis, personal fees from Galmed, personal fees from Opko, personal fees from NHLBI, personal fees from NICHD, personal fees from Vivus, personal fees from Genentech, personal fees from Reata Pharmaceuticals, personal fees from GW Pharmaceuticals, personal fees from Roche, personal fees from Orphazyme, personal fees from Horizon Pharmaceuticals, personal fees from Merck/Pfizer, personal fees from Klein-Buendel, personal fees from TG Therapeutics, personal fees from

List of abbreviations:

MS	Multiple Sclerosis
NMSS	National Multiple Sclerosis Society
WWG	Wellness Working Group
RCT	Randomized Controlled Trial
HRQOL	Health-Related Quality of Life
NARCOMS	North American Research Committee on MS
ASA24	Automated Self-Administered 24-Hour
HEI-2015	Health Eating Index-2015
GLTEQ HCS	Godin Leisure-Time Exercise Questionnaire Health Contribution Score
PSS	Perceived Stress Scale
FSS	Fatigue Severity Scale
HADS	Hospital Anxiety and Depression Scale
MPQ	McGill Pain Questionnaire
PSQI	Pittsburg Sleep Quality Index
MSIS-29	29-Item Multiple Sclerosis Impact Scale
PDDS	Patient Determined Disease Steps

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Table 1

Participant Demographic and Clinical Characteristics, N=123

Variable, *units*	
Age, *years*	**Mean±SD** 60.6±10.0
MS Duration, *years*	23.0±9.7
	Median(IQR)
PDDS (0–8)	7(0)
Sex	**n(%)**
Female	93(75.6)
Male	30(24.4)
Marital Status	
Married	75(61.0)
Single/Divorced/Widowed	48(39.0)
Employed	
Yes	15(12.2)
No	108(87.8)
Race	
Caucasian	105(85.4)
Other	18(14.6)
Education	
High School-Some College	36(29.3)
College Graduate or More	87(70.7)
MS Clinical Course	
Progressive	101(82.1)
Relapsing-remitting	22(17.9)
Type of Wheelchair	
Manual	49(39.8)
Power	62(50.4)
Scooter	12(9.8)

Note. PDDS: Patient Determined Disease Steps; MS: multiple sclerosis.

Table 2

Mean Behavioral Risk Factors and Symptoms, N=123

Variable, *Measure*	Mean±SD
Behavioral Risk Factors [*]	
Healthy Eating Index-2015, *Dietary Recall*	60.4±14.1
Health Contribution Score, *Godin Leisure Time Exercise*	
Questionnaire	6.9±16.0
Stress, *Perceived Stress Scale*	13.9±7.2
Symptoms	
Fatigue, *Fatigue Severity Scale*	4.8±1.6
Depression, *Hospital Anxiety and Depression Scale*	6.9±3.7
Anxiety, *Hospital Anxiety and Depression Scale*	4.8±3.3
Sleep Quality, *Pittsburg Sleep Quality Index* [†]	8.3±3.8
Health-Related Quality of Life, *Multiple Sclerosis Impact Scale* [†]	
Physical	59.4±19.3
Psychological	32.1±21.6
Pain, *McGill Pain Questionnaire*	10.3±8.2

Note.

[*] Cutoff scores for Healthy Eating Index-2015 54, Health Contribution Score <14, and Stress 27;

[†] Three cases missing.

Table 3

Prevalence and Patterns of Behavioral Risk Factors, N=123

Number of Behavioral Risk Factors	Poor Diet	Insufficient Physical Activity	Stress	Pattern Prevalence n(%)
0	No	No	No	7(5.7)
1	Yes	No	No	2(1.6)
	No	Yes	No	34(27.6)
	No	No	Yes	5(4.1)
2	Yes	Yes	No	20(16.3)
	No	Yes	Yes	27(22.0)
	Yes	No	Yes	2(1.6)
3	Yes	Yes	Yes	26(21.1)

Table 4

Bivariate Correlations Examining Number of Behavioral Risk Factors and Symptoms, N=123

Variable	Correlation with Number of Behavioral Risk Factors	
	Spearman's	Pearson's
Fatigue	.24 [**]	.22 [*]
Depression	.36 [***]	.39 [***]
Anxiety	.43 [***]	.45 [***]
Sleep Quality	.25 [**]	.29 [**]
Physical HRQOL	.30 [***]	.31 [***]
Psychological HRQOL	.47 [***]	.52 [***]
Pain	.16	.15

Note. HRQOL= Health-Related Quality of Life.

[*]
$p<.05$,

[**]
$p<0.01$,

[***]
$p<.001$

Table 5

Mann-Whitney U Test Examining Independent Associations between Symptoms and Number of Behavioral Risk Factor by Groups, N=123

Variable	U	n1	Mean(SD) n1	n2	Mean(SD) n2	P	η^2
Fatigue	1451.5	48	4.4(1.8)	75	5.0(1.5)	.07	.03
Depression	1046.0	48	5.3(3.4)	75	7.9(3.6)	.001	.13
Anxiety	989.0	48	3.4(2.7)	75	5.7(3.3)	.001	.15
Sleep Quality	1108.5	47	6.9(3.7)	73	9.2(3.7)	.001	.09
Physical HRQOL	1227.5	47	53.9(18.3)	73	63.0(19.3)	.009	.06
Psychological HRQOL	802.0	47	20.7(15.8)	73	39.4(21.8)	.001	.20

Note. HRQOL= Health-Related Quality of Life.