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Restricted Access to the Environment and Quality of Life in Adult Survivors of Childhood Brain Tumors

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Abstract

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

Background: Survivors of pediatric brain tumors are at-risk for late effects which may affect mobility within and access to the physical environment. This study examined the prevalence of and risk factors for restricted environmental access in survivors of childhood brain tumors and investigated the associations between reduced environmental access, health-related quality of life (HRQOL), and survivors' social functioning.

Methods: In-home evaluations were completed for 78 brain tumor survivors and 78 population-based controls matched on age, sex, and zip-code. Chi-square tests and multivariable logistic regression models were used to calculate odds ratios (OR) and 95% confidence intervals (CI) for poor environmental access and reduced HRQOL.

Results: The median age of survivors was 22 years at the time of study. Compared to controls, survivors were more likely to report avoiding most dimensions of their physical environment, including a single flight of stairs ($p<0.001$), uneven surfaces ($p<0.001$), traveling alone ($p=0.01$), and traveling to unfamiliar places ($p=0.001$). Overall, survivors were 4.8 times more likely to report poor environmental access (95% CI, 2.0-11.5, $p<0.001$). In survivors, poor environmental access was associated with reduced physical function (OR=3.6, 95% CI, 1.0-12.8, $p=0.04$), general health (OR=6.0, 95% CI, 1.8-20.6, $p=0.002$), and social functioning (OR=4.3, 95% CI, 1.1-17.3, $p=0.03$).

Conclusions: Adult survivors of pediatric brain tumors were more likely to avoid their physical environment than matched controls. Restricted environmental access was associated with reduced HRQOL and diminished social functioning. Interventions directed at improving physical mobility may have significant impact on survivor quality of life.

Keywords

CNS malignancies; survivorship; quality of life; environmental access

INTRODUCTION

Malignancies of the central nervous system account for nearly 20% of pediatric cancers in the United States [1]. While over 70% of children diagnosed with brain tumors achieve long-term survival, the consequences of tumor location within the CNS are considerable. Musculoskeletal, sensory, endocrine, neurologic, and cognitive complications have been documented [2].

Many late effects of pediatric brain tumors (BTs) become life-long chronic conditions and may adversely impact functional outcomes [3, 4]. Survivors are at-risk for restrictions in personal care and activities of daily living, including reduced school and work attendance [5]. Physical performance deficits are present in as many as 55% of BT survivors [4-6] with such impairments leading to limited participation in social roles [6] as well as contributing to diminished health-related quality of life (HRQOL) [7].

We recently described physical performance in a cohort of young adult survivors of childhood BTs that paralleled performance among adults in the sixth decade of life [6]. Impairments in muscle weakness, balance, and exercise tolerance were observed. Importantly, in older adults, these physical impairments are predictive of mobility disability,

including restricted ability to navigate the physical environment [8, 9]. As young adult BT survivors exhibit physical performance deficits comparable to older adults, they may have a similar trajectory of disability, suggesting the need to better understand how mobility deficits impact the ability of survivors to interact with their environment.

Reduced engagement with the environment may have deleterious effects on social interactions, physical health status, and HRQOL in survivors of childhood BTs. To our knowledge, the extent to which BT survivors access or avoid their physical environment, and how this may be related to functional status, has not been investigated. The study aims were to (1) examine the prevalence of and risk factors for restricted environmental access in survivors, and (2) investigate the association between reduced environmental access, HRQOL, and the ability of survivors to participate in social roles.

MATERIALS AND METHODS

Participants

BT survivors ≥18 years of age, diagnosed <21 years of age, and treated between 1970 and 2000 were randomly recruited in blocks of 20 from St. Jude Children's Research Hospital and the University of Minnesota Children's Hospital. A population-based comparison group, without a history of childhood cancer, was enrolled and frequency matched to survivors by age group, sex, and zip-code using Melissa data services. Participants were compensated for participation. Home visits were performed to eliminate potential participation bias due to inability to travel. The study was approved by the institutional review boards at both hospitals. Informed consent was obtained from each study participant or legal guardian. See Ness et al [6] for additional details regarding participant recruitment.

Primary Outcomes

Environmental Access—The Environmental Analysis of Mobility Questionnaire (EAMQ) was used to assess environmental access over the past month [9, 10]. The EAMQ includes a series of questions that ask participants to indicate how frequently they encounter and avoid their physical environments. Questions encompass eight dimensions of the environment: distance (e.g., walking ten blocks), temporal (e.g., busy street), ambient (e.g., lighting), terrain (e.g., stairs), physical load (e.g., heavy objects), postural demand (e.g., reaching), attention (e.g., noise), and density (e.g., crowding). Each dimension has questions for avoidance and encounter frequency, which are not mutually exclusive. The overall avoidance and encounter scores were calculated separately by summing respective scores. The total score is a ratio of overall avoidance/overall encounter. Total avoidance/encounter ratios ≥0.5 were classified as poor environmental access. The EAMQ has high test-retest reliability for all dimensions as well as summary encounter and avoidance scores [9]. Participants also answered questions specific to social participation, including the the number of times each month they travel to specific places (e.g., friend's home, restaurant, bank).

Health Related Quality of Life—HRQOL was measured using the Medical Outcomes Survey 36-Item Short Form Health Survey (SF-36) [11], Satisfaction with Life Scale

(SWLS) [12], and Visual Analog Scale (VAS) [13]. The SF-36 is widely used and provides subscale scores for eight domains of HRQOL: general health, role physical, physical function, bodily pain, vitality, mental health, social function, and role emotional. Age and sex-specific norms were utilized and T-scores ≤40 were classified as poor HRQOL. The SWLS is a five-item questionnaire utilizing a 7-point Likert scale response format and provides a global measure of life satisfaction [12]. Scores ≤17 were classified as representing poor life satisfaction. The VAS is a single-item measure on which participants indicate their quality of life on a continuous line, anchored by 'best possible' and 'worst possible' quality of life [14].

Social Participation—Participants were asked open-ended questions about employment and current living situation. Employment was categorized as employed or student vs. unemployed, whereas independent living was categorized as living independently vs. living with family support or custodial care..

Predictors and Covariates

Demographic and Treatment Information—Demographic information was collected from study participants and/or caregivers/legal guardians. Four survivors required caregiver assistance to answer questions related to demographic information. Treatment information was obtained from medical records using trained data abstractors. Tumor type, surgical interventions, chemotherapy agents and doses, and. cranial and spinal radiation doses were recorded. Consistent with the approach described by Packer et al. [15], four different anatomic segments (frontal cortex, temporal lobe, posterior fossa, and parietal or occipital lobe) were identified and the maximum dose was estimated.

Physical Performance—Physical performance limitations were assessed with the Physical Performance Test (PPT) [16] and the Functional Status Index (FSI) [17]. The 7-item PPT includes a series of timed tasks: writing a sentence, eating, dressing, picking up a small object, placing an object on a shelf, standing and turning, and walking. Higher scores on the PPT indicate better physical performance [16]. The FSI is a self-report questionnaire that measures physical performance in three dimensions: assistance, difficulty, and pain. Lower scores on the FSI indicate less disability [17].

Cognitive Function—Cognitive performance was evaluated with the Kaufman Brief Intelligence Test–Version 2 (KBIT-2) [18], which provides an overall Intelligence Quotient (IQ) Composite. Age-adjusted scores were calculated based on population norms (M=100, SD=15) and scores falling ≤10th percentile were classified as impaired cognitive function.

Psychological Distress—Psychological distress was measured by the Brief-Symptom Inventory-18 (BSI-18) [19]. Sex-specific scores were calculated using standardized normative values (M=50, SD=10) and scores falling ≥90th percentile on the Global Severity Index (GSI) were classified as clinical levels of acute distress. This measure has previously been validated in adult survivors of childhood cancer [20].

Statistical Analysis

Descriptive statistics were calculated for survivor and comparison group demographic characteristics. Percentages for encounters and avoidances within each environmental dimension were compared between groups with the Chi-Square test or Fisher's exact test. Multivariable linear regression models were used to compare the overall avoidance/encounter ratio and social participation between survivors and controls. Multivariate logistic regression was used to identify predictors of poor environmental access. Reduced HRQOL was examined with the Chi-Square test and odds ratios (OR) and 95% confidence intervals (CI) are reported. Associations between clinical and treatment variables and environmental access were evaluated using linear regression models; associations between poor environmental access and reduced HRQOL were evaluated with the Chi-Square test; and associations between poor environmental access and social outcomes were evaluated with logistic regression models.

RESULTS

Participants

Participants included 78 of the first 132 eligible BT survivors who were randomly selected for contact. BT participants did not differ from nonparticipants by sex, current age, age at diagnosis, years since diagnosis, or tumor type ($p>0.50$). Members of the population-based comparison group included 78 of 99 randomly selected individuals. See Figure 1 for a consort diagram of study participation. Sex and race distributions of BT survivors and comparison group members were identical. Comparison group members were slightly older (median 25 years; range 18-54 years) than BT survivors (median 22 years; range 18-58 years). Twenty-one survivors (27%) were treated with surgery only. Table 1 provides additional descriptive characteristics of survivors.

Environmental Access

Across nearly all environmental dimensions, survivors were significantly more likely to report avoiding aspects of the physical environment compared to controls (Table 2). Specifically, survivors were significantly more likely to avoid navigating different environmental terrains, including a single flight of stairs (25.6% vs. 5.1%; $p<0.001$), curbs (20.5% vs. 2.6%; $p<0.001$), and uneven surfaces (28.2% vs. 5.1%; $p<0.001$), as well as traveling alone (48.7% vs. 28.2%; $p=0.01$) and to unfamiliar places (42.3% vs. 19.2%; $p=0.001$). Survivors were significantly more likely to report that they did not drive compared to controls (46.1% vs. 3.8%, $p<0.01$).

After adjusting for age and sex, survivors ($M=0.44$, $SD=0.27$) were more likely to have a higher total avoidance to encounter ratio compared with controls ($M=0.24$, $SD=0.27$), reflecting poorer environmental access across multiple dimensions ($p<0.001$). Specific differences were observed on the distance ($p=0.004$), ambient ($p=0.03$), terrain ($p<0.001$), physical load ($p<0.001$), postural demand ($p=0.01$), and attention dimensions ($p<0.001$) of the EAMQ. In a multivariable logistic regression model adjusting for age, sex, climate of the community, and employment status, survivors were 4.8 times more likely to report poor

environmental access compared to controls (95% CI, 2.0-11.5; p<0.001) (Online Resource 1).

In analyses restricted to survivors, controlling for age and sex, we found that impaired cognition (p=0.002), lower physical performance (p=0.007), and reduced functional status (p=0.001) were significantly associated with restricted environmental access, though psychological distress was not (p=0.12). Vision loss (p=0.33), hearing loss (p=0.90), and obesity (p=0.27) were not significantly associated with access to the environment. A larger proportion of survivors who did not drive reported restricted environmental access (p=0.04), though no difference was observed in survivors treated with seizure medications (p=0.09). Results from a multivariable regression model examining the associations between treatment exposures and environmental access are provided in Table 3. Older age at the time of study completion was the only significant predictor of poor environmental access in survivors (p=0.03).

Health-Related Quality of Life

In unadjusted analyses, survivors were significantly more likely to report reduced HRQOL than comparison group members across several domains including physical function (OR=9.97, 95% CI, 2.21-45.0, p<0.001), role physical (OR=21.8, 95% CI, 2.82-168.6, p<0.001) general health (OR=23.5, 95% CI, 3.05-181.0, p<0.001), and bodily pain (OR=7.72, 95% CI, 1.68-35.5, p=0.003). No significant differences were reported on the VAS or SWLS. Among survivors, those with poor environmental access were more likely to report diminished vitality (OR=4.44, 95% CI=1.09-18.0, p=0.03) and restricted social function (OR=4.27, 95% CI=1.05-17.3, p=0.03) (Table 4).

Social Participation

In multivariable models adjusting for age and sex, survivors differed from controls with respect to the overall frequency in which they engaged in functional living and social activities in their community (p=0.003). Specifically, survivors reported going to a bank (p=0.048), friend's home (p=0.003), and restaurant or café (p=0.035) less frequently each month compared to controls.

Forty-three percent of survivors who reported poor environmental access were living independently. In contrast, 80% of survivors reporting satisfactory environmental access were living independently, although this difference was not statistically significant. The association between employment status and environmental access approached statistical significance, indicating that survivors with poor environmental access were less likely to be currently employed (OR=0.36, 95% CI, 0.12-1.04, p=0.06).

DISCUSSION

To our knowledge, this is the first study to report on environmental access and its impact on HRQOL and social participation in a cohort of adult survivors of childhood BTs. The results indicate that BT survivors are more likely to avoid specific aspects of their physical environment compared to individuals of the same age, sex, and living in the same communities. Additionally, survivors were less likely to engage in expected social activities

and roles within their communities. Poor environmental access was associated with reduced HRQOL among survivors. These results suggest that access to the physical environment has important consequences for daily functioning and social integration of BT survivors.

Beyond reporting reduced environmental access, we found that survivors were more likely to actively avoid many aspects of their physical environment than comparison adults. Specifically, survivors were more likely to avoid dark conditions, uneven terrain, physical demands, unfamiliar places, and traveling alone. Importantly, the use of a zip-code matched comparison group reduced the influence of potentially confounding aspects of the immediate physical environment (i.e., climate, street lighting, public transportation) on environmental access. Consistent with other studies, our results show that actively avoiding aspects of the physical environment has the potential to restrict daily functioning [9]. Accordingly, we found that survivors were less likely to engage in developmentally appropriate functional activities such as working, banking, and living independently. Further, survivors were less likely to engage in social activities including going to a friend's home or going out to a restaurant. These findings are similar to reports that adult survivors of childhood BTs are more socially isolated [21] and experience less social independence [22] than their healthy counterparts. However, our results further suggest that social restrictions may be related to reduced environmental access.

In this cohort, survivors with lower physical performance scores, reduced functional status, and impaired cognition were more likely to report restricted environmental access than survivors who did not demonstrate such deficits. In older adults, similar patterns of physical functioning have been identified as precursors to mobility disability [8] which may be mediated by components of the physical environment [9]. As such, interventions with the potential to reduce environmental barriers may be a critical step toward preventing the onset of mobility disability in survivors. Such intervention efforts should capitalize on promoting access to and utilization of existing services and assistive technologies for individuals with disabilities. Targeted efforts to enhance independent mobility, balance, and coordination through individualized rehabilitation programming will also be important.

The association between environmental access and HRQOL has not previously been reported in survivors of childhood BTs, but is consistent with research among brain and spinal cord injury patients. Access to the environment has been associated with positive life satisfaction in adults with spinal cord injury [23], while environmental barriers are associated with reduced life satisfaction in patients with brain [24] and spinal cord injuries [25]. Similarly, we found that poor environmental access was associated with reduced physical function, general health, vitality, and social functioning. It is important to consider the potential bidirectional associations between these factors. Specifically, limitations on measures of physical performance and functional status were associated with poor environmental access, which may result in difficulty navigating the physical environment. However, actively avoiding one's physical environment may precipitate or exacerbate risks for health problems associated with inactivity. Likewise, restricting oneself from accessing the environment and participating in social opportunities may potentiate feelings of isolation.

While we did not find an association between treatment variables and environmental access in survivors, older age significantly predicted poor environmental access. Previous literature suggests that disabled older adults are more likely to report avoidance of physical challenges in their environment than are nondisabled older adults [10]. Although our sample was previously reported to demonstrate greater physical performance limitations than matched comparisons [6], it is important to note that the median age for survivors in our study was only 22 years. This suggests that even young adult BT survivors may be vulnerable to barriers restricting mobility within the physical environment. These findings have important implications as physical activity and social engagement are known contributors to cardiovascular [26, 27], cognitive [28], and emotional health, [29, 30] and are likely of high import for survivors with established risk for developing chronic health conditions [3].

Several limitations need to be considered when interpreting these results. The participation rate among survivors was only 59%, thus survivors who participated may have worse or better environmental access than those who did not participate. However, every effort was made to allow eligible participants to enroll by performing evaluations in their homes and offering flexibility with timing of visits. Survivors in our study were recruited from pediatric oncology centers and may not represent the larger population of BT survivors, including those primarily treated and followed at neuro-surgical centers. Given the small number of survivors reporting reduced HRQOL and restricted social outcomes we had limited power to detect statistically significant associations between these variables and poor environmental access. Moreover, environmental access was based on self-report. Observing survivors interact with and negotiate their physical environment may provide insight into specific environmental barriers and potential intervention targets for these patients.

In summary, adult survivors of childhood BTs report, on average, worse environmental access, HRQOL, and social participation than age, sex, and zip-code matched comparisons. In survivors, limited access to the environment is associated with reduced HRQOL. Given the potential consequences of restricted environmental access on physical, social, and cognitive health, intervention efforts directed at increasing survivor engagement in their physical environments may be warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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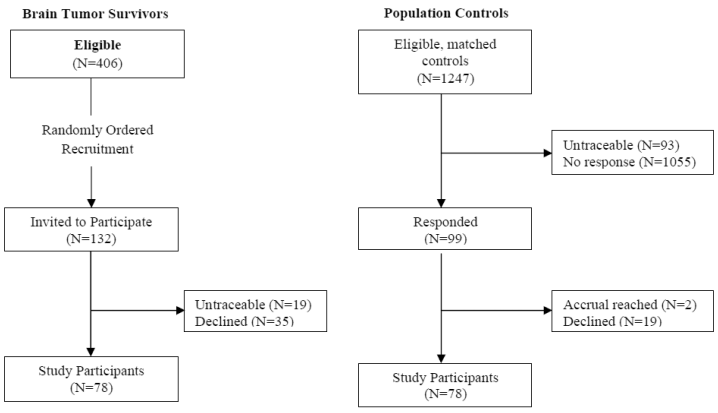

Fig. 1.
Consort diagram of study participation

Table 1

Characteristics of brain tumor survivors

	Survivors (N=78)	
	N	**%**
Sex		
Female	36	46
Male	42	54
Age at Diagnosis, years		
<5	22	28.2
5-9	26	33.3
10-14	21	26.9
15-20	9	11.5
Time since Diagnosis, years		
5-9	12	15.4
10-14	30	38.5
15-19	22	28.2
>20	14	17.9
Tumor Type		
Astrocytic	40	51.3
Medulloblastoma	13	16.7
Ependymoma	9	11.5
Other	16	20.5
Extent of Surgery		
None/or Biopsy Only	18	23.1
Partial/Near Total Resection	24	30.8
Gross Total Resection	36	46.1
Chemotherapy		
Yes	24	30.8
No	54	69.2
Radiation		
None	26	33.3
Cranial	29	37.2
Craniospinal	23	29.5
	Median	**Range**
Segment Specific Dose, cGy[a]		
Spine	3600	2430-6050
Posterior Fossa	5070	0-7020
Temporal Lobe	5040	0-7200
Frontal Cortex	3520	0-6000
Occipital/Parietal Lobe	3520	0-7020

[a] cGy indicates centigray. Includes dose and boost to tumor bed.

Table 2

Environmental dimensions avoided and encountered by survivors and controls

	Encounter			Avoidance		
Dimension	**Survivor N (%)**	**Control N (%)**	**p-value**	**Survivor N (%)**	**Control N (%)**	**p-value**
Distance						
Walk long distances	46 (59.0)	48(61.5)	0.90	35 (44.9)	24 (30.8)	0.05
Temporal						
Cross street with light	50 (64.1)	56 (71.8)	0.42	22 (28.2)	20 (25.6)	0.65
Cross busy street	54 (69.2)	49 (62.8)	0.28	34 (43.6)	22 (28.2)	0.03
Ambient						
Dark	67 (85.9)	76 (97.4)	0.03	32(41.0)	17(21.8)	0.01
Rain	64(82.1)	71 (91.0)	0.20	30(38.5)	20 (25.6)	0.07
Snow	60 (76.9)	62 (79.5)	0.93	38 (48.7)	30(38.5)	0.15
Ice	24 (30.8)	34 (43.6)	0.12	44 (56.4)	41 (52.6)	0.51
Terrain						
Single flight of stairs	61 (78.2)	63 (80.8)	0.94	20 (25.6)	4(5.1)	<0.001
Two flights of stairs	51 (65.4)	51 (65.4)	0.82	24 (30.8)	11 (14.1)	<0.01
Escalator	41 (52.6)	31 (39.7)	0.08	16 (20.5)	5 (6.4)	<0.01
Curbs	62 (79.5)	65 (83.3)	0.77	16 (20.5)	2 (2.6)	<0.001
Uneven Surfaces	62 (79.5)	69 (88.5)	0.23	22 (28.2)	4(5.1)	<0.001
Physical Load						
Carry heavy objects	61 (78.2)	74 (94.9)	0.01	40(51.3)	21 (26.9)	0.001
Open heavy doors	53 (68.0)	65 (83.3)	0.05	15 (19.2)	0(0)	<0.001
Postural Demand						
Reach above shoulders	62 (79.5)	71 (91.0)	0.09	14(18.0)	3 (3.9)	<0.01
Reach below knees	67 (85.9)	69 (88.5)	0.95	11 (14.1)	3 (3.9)	0.02
Attention						
Travel alone	67 (85.9)	72 (92.3)	0.39	38 (48.7)	22 (28.2)	0.01
Noisy or busy places	61 (78.2)	70 (89.7)	0.10	20 (25.6)	13 (16.7)	0.14
Unfamiliar places	51 (65.4)	62 (79.5)	0.08	33 (42.3)	15 (19.2)	0.001
Density						
Crowded places	44 (56.4)	61 (78.2)	0.01	32(41.0)	24 (30.8)	0.14

Table 3

Impact of treatment on the EAMQ (entire scale) in survivors

	Univariate			Multivariable		
	Mean (SD)	**95% CI**	**p-value**	**LS mean (SE)**	**95% CI**	**p-value**
Age at evaluation, years	-	-	0.003	-	-	0.03
Age at diagnosis, years						
<5	0.56 (0.27)	0.44-0.68	0.05	0.47 (0.08)	0.31-0.63	0.76
5-20	0.40 (0.32)	0.31-0.49		0.45 (0.05)	0.34-0.55	
Sex						
Male	0.40(0.33)	0.29-0.51	0.19	0.44 (0.06)	0.31-0.57	0.60
Female	0.50 (0.29)	0.40-0.59		0.48 (0.06)	0.35-0.61	
Segmental radiation						
Posterior fossa/spine						
No	0.42 (0.34)	0.31-0.54	0.51	0.59 (0.09)	0.41-0.76	0.08
Yes	0.47 (0.28)	0.38-0.57		0.34 (0.09)	0.16-0.52	
Temporal lobe						
No	0.37(0.34)	0.25-0.50	0.10	0.36 (0.09)	0.18-0.55	0.09
Yes	0.50 (0.29)	0.41-0.58		0.56 (0.06)	0.44-0.68	
Frontal cortex						
No	0.38(0.33)	0.28-0.48	0.04	0.37(0.08)	0.21-0.52	0.17
Yes	0.53 (0.28)	0.43-0.63		0.56 (0.09)	0.37-0.74	
Occipital/parietal lobe						
No	0.42 (0.33)	0.32-0.52	0.40	0.48 (0.09)	0.29-0.66	0.81
Yes	0.48 (0.29)	0.38-0.59		0.44 (0.08)	0.29-0.60	
Shunt placement						
No	0.41 (0.30)	0.33-0.50	0.18	0.42 (0.06)	0.30-0.55	0.32
Yes	0.52(0.35)	0.37-0.66		0.50 (0.07)	0.37-0.63	
Tumor type						
Astrocytic	0.44 (0.33)	0.33-0.55	0.15	0.45 (0.06)	0.32-0.58	0.22
Medulloblastoma	0.56(0.23)	0.42-0.71		0.50(0.10)	0.31-0.70	
Ependymoma	0.53 (0.30)	0.31-0.76		0.59(0.12)	0.35-0.83	
Other	0.31(0.32)	0.14-0.49		0.30(0.10)	0.11-0.49	
Chemotherapy						
No	0.41 (0.32)	0.33-0.50	0.17	0.48 (0.07)	0.35-0.61	0.77
Yes	0.53 (0.29)	0.40-0.65		0.45 (0.08)	0.28-0.61	

Table 4

Restricted environmental access and reduced health-related quality of life in survivors

	Physical Function		Role Physical		General Health		Bodily Pain		VAS[a]	
	N(%)	OR(95%CI)	N(%)	OR(95%CI)	N(%)	OR(95%CI)	N(%)	OR(95%CI)	N(%)	OR(95%CI)
Restricted	10(28.6)	3.6(1.0-12.8)	13(37.1)	7.3(1.9-28.5)	14(40.0)	6.0(1.8-20.1)	9(25.7)	3.1(0.9-11.2)	6(17.7)	4.1(0.8-21.7)
Unrestricted	4(10.0)	1.0	3(7.5)	1.0	4(10.0)	1.0	4(10.0)	1.0	2(5.0)	1.0
	Mental Health		Role Emotional		Social Function		Vitality		SWLS[b]	
	N(%)	OR(95%CI)	N(%)	OR(95%CI)	N(%)	OR(95%CI)	N(%)	OR(95%CI)	N(%)	OR(95%CI)
Restricted	4(11.8)	0.9(0.2-3.8)	7(20.0)	3.1(0.7-13.0)	9(25.7)	4.3(1.1-17.3)	9(26.5)	4.4(1.1-18.0)	8(23.5)	3.8(0.9-15.7)
Unrestricted	5(12.5)	1.0	3(7.5)	1.0	3(7.5)	1.0	3(7.5)	1.0	3(7.5)	1.0

[a] VAS=visual analog scale.

[b] SWLS=satisfaction with life scale.