Work Productivity in Brain Tumor Survivors

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Objective: *To determine the association of symptom burden to work limitation among working survivors of malignant brain tumors.* ***Methods:*** *Working adults with malignant brain tumors (n = 95) and a non-cancer comparison (n = 131) group completed a web-based questionnaire. Measures of demographics, tumor type and treatment, fatigue, emotional distress, cognitive limitations, and factors that can positively impact work, including health behaviors and problem solving, were obtained.* ***Results:*** *Survivors of malignant brain tumors reported higher levels of work limitations and time off from work than the non-cancer group. Higher levels of symptom burden, lower levels of health behaviors, and more negative problem solving orientation were characteristic of the brain tumor survivor group. These variables were not differentially associated with work limitations among brain cancer survivors or the comparison group. Depressive symptoms, fatigue, cognitive limitations, sleep, and negative problem solving orientation were independently associated with work limitations, accounting for 65% of the variance in work limitations.* ***Conclusions:*** *Despite higher levels of burden, poorer health behaviors, and negative problem solving coping style, modifiable factors account for most of the variance in work limitations for both groups. Efforts to modify these variables should be evaluated.* (J Occup Environ Med. *2007;49:803–811*)

While there is emerging research indicating that many cancer survivors adapt over time,[1] as with other health problems, the long term symptom burden in cancer survivors and its relationship to work may go unrecognized.[2] A recent population health study of a heterogeneous group of cancer survivors indicated that 11 years post diagnosis, cancer survivors reported greater limitations at work than a non-cancer comparison group.[3] Also, a study of a mixed group of cancer survivors 5 years post diagnosis found that 20% continued to report that cancer related problems impact their function at work.[4] These work difficulties have been attributed to physical, cognitive, and emotional challenges that some survivors experience.[5] Studies of other chronic illnesses demonstrate that work limitations can lead to psychological distress[6] and contribute to long terms problems in the workplace.

It has been recognized for years that fatigue at a muscular level can effect work.[7] The nature of fatigue in cancer survivors has been categorized as different qualitatively and perhaps physiologically than general muscular or whole body fatigue.[8] Also episodic or prolonged heightened levels of fatigue can remain a problem for years following initial treatment for cancer.[9] Spelleden and colleagues[10] have observed high levels of fatigue in a working cohort of heterogeneous cancer survivors independent of diagnosis, treatment, age, and gender. Changes in neurocognitive and motor abilities including working memory, executive function, attention, and motor function are also commonly observed in many types of cancer survivors.[11]

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This research was funded by an intramural grant awarded to Michael Feuerstein, PhD, MPH From the Uniformed Services University of the Health Sciences and the Cancer Survivorship Fund, Henry M Jackson Foundation.

The opinions and assertions contained herein are the private views of the authors and are not to be construed as being official or as reflecting the views of the Uniformed Services University of the Health Sciences or the Department of Defense.

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DOI: 10.1097/JOM.0b013e318095a458

While less is known about symptom burden in survivors of brain tumors, long term changes in emotions, cognition, and health behaviors have often been observed.[12–14] These problems have the potential to impact the ability to efficiently perform many tasks involved in work.

The present study investigated the role of both non-modifiable (eg, demographics, tumor type, and treatment) and modifiable factors in brain tumor survivors and their association to work limitations. A cross-sectional design was used to investigate the relative contribution of fatigue, job stress, anxiety and depressive symptoms, cognitive limitations, health behaviors, and problem solving approach in brain tumor survivors. It was hypothesized that the brain tumor group would have greater symptom burden than the comparison group and this would differentially influence the association with work limitation, where the brain tumor group would demonstrate a stronger relationship with work limitation than the non-cancer group.

Materials and Methods

Procedure

An internet-based survey was generated and placed on-line.[15] The questionnaire and corresponding data were hosted on a secure site. Completion of an on-line consent form was required prior to accessing the questionnaire. The on-line assessment required an average of 1 hour and 45 minutes to complete. The Internal Review Board at USUHS and American University approved the study. Participants had an option of submitting a name and address to receive a "LIVESTRONG" wristband and a check for modest compensation ($15.00 US).

Case Definition

Inclusion criteria included age 20 to 70 years, both genders and all ethnicities, a minimum of a 7th grade English reading level, and working full or part time. Adult brain tumor survivors were recruited from the Brain Tumor Society, the American Brain Tumor Association, and the National Brain Tumor Foundation. In addition, an announcement was posted on the American Cancer Society Cancer Survivor Network. Brain tumor survivors and non-cancer comparisons were recruited from advertisements placed in the Washington Post, the Los Angeles Times, and the NIH Record.

Cancer survivor participants included those with a patient-reported history of malignant brain tumors that indicated a history of work for at least one year prior to diagnosis. They did not report other (ie, non-cancer) chronic illnesses. Brain tumor participants had one of the following primary malignant brain tumors: glioblastoma, astrocytoma, oligodendroglioma, ependymoma, and malignant glioma not otherwise specified (NOS). Brain tumor participants were required to have completed primary treatment (eg, surgery, radiation, chemotherapy). The sample was a selected group of survivors of serious life threatening malignant brain tumors following primary treatment and working full time.

The non-cancer comparison group was employed and did not report any life threatening illness or major chronic disease. They needed to be employed full-time for at least one year prior to completing the questionnaire. The comparison group was included to determine whether differences were observed between the two groups on symptom burden and mitigating variables that could differentially impact work limitations.

Measures

Medical Status. Participants were asked to complete questions on medical history including type of tumor, stage of tumor, treatment received (surgery, radiation, and/or chemotherapy), dose of radiation, months on chemotherapy, month and year of diagnosis, medications, comorbid health conditions, and health insurance status. This information, while presented in a forced choice format was based on patient report.

Anxiety and Depression. The Hospital Anxiety and Depression Scale (HADS) was developed to measure depression and anxiety in general medical populations[16] and was specifically designed to assess the emotional component of physical illness. It consists of two subscales, Anxiety (A-scale) and Depression (D-scale). Bjelland and colleagues[17] reported that the HADS-A had an average internal consistency of $\alpha = 0.83$ while the HADS-D had an average $\alpha = 0.82$. When administered to a sample of cancer survivors of head and neck cancer, the HADS demonstrated greater sensitivity, specificity, and positive predictive values than either the Beck Depression Inventory or the Centre for Epidemiological Studies-Depression.[18] The HADS was included in the present study to detect symptoms common to depression and anxiety.

Problem Solving Inventory. The Social Problem Solving Inventory (SPSI-R) measures both adaptive problem-solving dimensions and non functional dimensions (eg, negative problem orientation, impulsivity/carelessness style, and avoidance style).[19,20] The SPSI-R has a test-retest reliability of $r = 0.87$ and internal consistency of $\alpha = 0.94$.[20] This study used the negative problem solving orientation subscale as a measure of difficulties with problem solving.

Fatigue. The Multidimensional Fatigue Symptom Inventory-Short Form (MFSI-SF) is a self-report measure that includes five symptom domains including general fatigue, physical fatigue, emotional fatigue, mental fatigue, and vigor.[21] The internal consistency of the MFSI-SF ranges from $\alpha = 0.87$ to 0.96. Test-retest reliability for the MFSI-SF subscales ranges from $r = 0.60$ to 0.70.[22] The physical fatigue subscale was used in the present study because the other subscales measure

psychosocial dimensions of fatigue. We were interested in capturing perceptions of physical fatigue.

Cognitive Function. The Cognitive Symptom Checklist (CSC) was originally developed as a patient checklist of cognitive problems.[23] It was used in the present study to measure self reported problems in neuropsychological function that impact day to day activities. The CSC is an index of disruption of tasks that require specific cognitive functions such a memory or attention. Each item required a dichotomous discrimination (ie, problem/no problem). The full CSC assesses five broad areas including attention/concentration, memory, visual processes, language, and executive function. Through the combination of factor analysis (varimax rotation) and setting the criteria for an item in a factor at 0.4 we reduced the measure to 59 item reflecting three subscales (working memory, executive functioning, and attention). The chronbach alpha values for the three factors were memory ($\alpha = 0.93$), executive functioning ($\alpha = 0.91$), and attention ($\alpha = 0.86$). This modified version of the CSC was used as a patient reported index of cognitive difficulties encountered by participants in daily life. This checklist can be obtained from the publisher.

Job Related Questions. Participants were also asked the type of employment (ie, managerial, sales, services, professional, clerical, agricultural, production, or other), length of time in their current job or last place of employment and how frequently they felt "stressed at work."

Health Behaviors. Questions from the Health Risk Appraisal[24,25] (currently the Behavioral Risk Factor Surveillance Survey[26]) were included to provide an assessment of the frequency of aerobic, strengthening, and stretching exercises. The frequency levels for each exercise type were rarely, one or two times per week, or at least three times per week. Smoking status (never smoked, used to smoke, still smoke), adequate nutrition (yes or no), and sufficient sleep (yes or no) were also measured. These have been used in the investigator's previous research and have been shown to be related to work disability.[25]

Work Limitations Questionnaire. Work limitations were measured using the Work Limitations Questionnaire (WLQ). The WLQ is a 25 item self-report measure of the impact of chronic health problems on work productivity. The WLQ includes subscales that assess time demands, physical demands, mental-interpersonal demands, and output demands. Each of these subscales has an internal consistency (α) of greater than 0.90.[27] Lerner et al.[28] reported that for every 10% increase on the WLQ, work productivity (as assessed by the rate of merchandise units processed per hour for a group of customer service representatives and return-department workers) declined approximately 4%. Higher levels of work limitations indicate lower levels of work productivity.

Data Analysis

χ^2 and t tests were performed to determine whether brain tumor survivors differed from the non-cancer participants on demographics, general health behaviors, and work characteristics. Separate multivariable regressions were computed for the brain tumor group and non-cancer comparison group to determine the relative contribution of demographics (age, gender, education, and marital status) and cancer and treatment related factors (for brain tumor survivors only) on work limitations. Linear regression was used to exclude variables for the final model that did not reach $P < 0.10$.

The final multivariable hierarchical regression model included the following in order of entry: cancer/non-cancer, job related (job stress), symptom burden (mood, fatigue, cognitive limitations), and variables that could potentially mitigate the impact of the others on work limitations (health behaviors and problem solving). The WLQ (mean score) was used as the dependent variable for the regression. A group interaction term was created for each of the symptom burden measures and the measures indicating lower levels of health protective behaviors and a more negative approach to problem solving. These were entered into the model because these factors particularly symptom burden measures tend to persist in cancer survivors years following diagnosis. Therefore, it was hypothesized that these variables may be differentially associated with higher levels of work limitations in the brain tumor survivor group that in those with without cancer.

Results

Demographic Variables

As Table 1 indicates there were significant group differences in gender ($\chi^2 = 10.2$, $P < 0.01$), education ($\chi^2 = 10.5$, $P < 0.05$), and marital status ($\chi^2 = 14.2$, $P < 0.05$). The groups did not differ on age, race, and health insurance status.

Clinical Characteristics

The most common brain tumor types were: oligodendroglioma, astrocytoma, and glioblastoma (see Table 2). Most tumors were categorized as stages II-IV. The majority of brain tumor survivors reported a history of neurosurgery, radiation, and chemotherapy, or combination treatment. Brain tumor survivors reported a range of chemotherapy of 1 to 29 months. Brain tumors were predominantly (54%) located in the right hemisphere. The mean time since diagnosis was 3.8 years (SD = 3.8).

The pattern of reported medication for both brain tumor participants and non-cancer comparisons is presented in Table 3. As expected, the brain tumor group reported taking more cancer-related ($\chi^2 = 14.4$, $P < 0.001$) and anti-convulsive medication ($\chi^2 = 102.5$, $P < 0.001$), while non-cancer comparison group reported using more vitamins/supple-

TABLE 1
Demographic Characteristics

	Brain Tumor (n = 95)		Non-Cancer Comparison (n = 131)	
	N	%	N	%
Age				
20–29	13	13.7	28	21.4
30–39	21	22.1	39	29.8
40–49	33	34.7	34	26.0
50–59	24	25.3	25	19.1
60–70	4	4.2	5	3.8
Gender*				
Female	56	58.9	103	78.6
Male	39	41.1	28	21.4
Education**				
Less than HS/HS/GED	6	6.3	7	5.4
Some college	17	17.9	16	12.2
AA or Bachelors	35	36.8	29	22.1
Some graduate school	9	9.5	21	16.0
Graduate degree	28	29.5	58	44.3
Marital status**				
Single	10	10.5	33	25.2
Cohabitating	4	4.2	10	7.6
Divorced/separated	9	9.5	15	11.4
Married	72	75.8	73	55.7
Race				
White	89	93.7	115	87.8
Non-white	6	6.3	16	12.2
Health insurance[a]				
Yes	89	93.7	125	95.4
No	5	5.3	6	4.6

*$P < 0.01$; **$P < 0.05$.
[a]One or more participants did not respond.

TABLE 2
Diagnosis and Treatment Characteristics

Brain (n = 95)	N	%
Tumor type		
Glioblastoma	18	18.9
Astrocytoma	34	35.8
Oligodendroglioma	36	37.9
Malignant Glioma	4	4.2
Ependymoma	3	3.2
Tumor location		
Right hemisphere	51	53.7
Left hemisphere	29	30.5
Bilateral	3	3.0
Front	20	21.1
Middle	11	11.6
Back	15	15.8
Tumor grade		
I	10	10.5
II	42	44.2
III	26	27.4
IV	17	17.9
Treatment type		
Chemotherapy	59	62.1
Radiation	64	67.4
Surgery	83	87.4
Other	8	8.4
Years since diagnosis*		
<1 yr	7	7.4
1 yr	27	28.4
2 yrs	16	16.8
3 yrs	8	8.4
4 yrs	6	6.3
5 yrs	7	7.4
6–10 yrs	15	15.8
11–37 yrs	6	6.3

*One or more participants did not respond.

ments ($\chi^2 = 4.6$, $P < 0.05$) and no medications ($\chi^2 = 4.8$, $P < 0.05$).

Health Behaviors

The χ^2 analyses conducted on the health behavior measures indicated that there were lower levels of aerobic exercise frequency ($\chi^2 = 12.1$, $P < 0.01$) and sufficient sleep ($\chi^2 = 16.6$, $P < 0.001$) in the brain tumor group. There were no differences between the groups on diet or smoking status.

Work Limitations

The t test for work limitations (assessed via the WLQ) indicated work limitations were greater for the brain tumor group M = 5.6, SD = 4.4, than the non-cancer comparison group M = 2.6, SD = 2.7 ($t = 6.2$; $P < 0.001$). Figure 1 illustrates this difference.

Other Work Characteristics

There were no differences between the two groups on type of work, months on the job, or general level of perceived job stress. Differences were found between the two groups on total days missed from work in the past year ($t = 5.5$, $P < 0.001$). These are presented in Table 4.

Symptoms/Problem Solving

Differences between groups were found for physical fatigue ($t = 3.8$, $P < 0.001$), depression ($t = 5.1$, $P < 0.001$), anxiety ($t = 2.7$, $P < 0.01$), patient reported cognitive limitations ($t = 6.8$, $P < 0.001$), and a negative problem solving outlook ($t = 2.1$, $P < 0.05$). The means and standard deviations for each group are presented in Table 5.

Factors Related to Work Limitations

In an effort to keep the number of independent variables from becoming too large given the sample size, we performed separate regressions for the brain tumor survivor group in order to determine the influence of demographics and medical and treatment characteristics on work limitations. We also performed a separate regression on the non-cancer comparison group to determine the contribution of demographics on work limitations. None of the independent variables were significantly related to work limitations, and thus were not included in the final model. Those variables that were related to the WLQ at $P < 0.10$ were included

TABLE 3
Medications

Brain	N	%	Non-Cancer Comparisons	N	%
Cancer related*	10	10.5	Cancer related	—	—
Cognitive difficulties	3	3.2	Cognitive difficulties	2	1.5
Mood	16	16.8	Mood	22	16.8
Anemia/fatigue	6	6.3	Anemia/fatigue	3	2.3
Supplements/vitamins**	37	38.9	Supplements/vitamins	70	53.4
Anti-convulsive/seizure*	59	62.1	Anti-convulsive/seizure	2	1.5
Other prescription	43	45.3	Other prescription	55	42.0
None**	11	11.6	None	30	22.9

*$P < 0.001$; **$P < 0.05$.

in the final regression model (job stress, time at current job, HADS depression and anxiety, fatigue, cognitive limitations, physical activity sleep, and negative problem solving orientation).

Both brain tumor and non-cancer comparison groups were entered into the final model. This was further justified because of the univariate differences between both groups on these measures. The main effect and interaction terms are presented. The regression coefficient for the main effect describes the change in work limitations for a one-unit change in the variable, in the brain tumor subgroup. The regression coefficient for the interaction describes how the regression coefficient in the non-cancer subgroup differs from the regression coefficient in the brain tumor subgroup. Overall, the model accounted for 63% of the variance in work limitations for brain tumor survivors and non-cancer comparisons. The individual contributions of each of the variables, beta weights, and levels of significance are presented in Table 6.

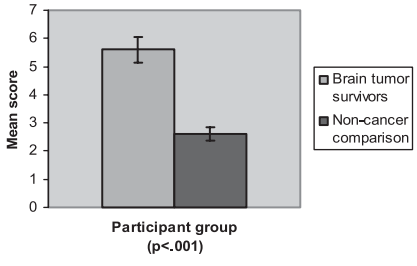

Fig. 1. Work limitations questionnaire.

The significant modifiable factors indicate the importance of depressive symptoms (B = 0.32; $P < 0.01$), fatigue (B = 0.21; $P < 0.01$), cognitive limitations (B = 0.22; $P < 0.01$), sufficient sleep (B = −0.17; $P < 0.05$), and negative problem solving (B = 0.15; $P < 0.05$) on work in both brain tumor survivors and the non-cancer comparison group.

Discussion

This study confirmed that those working with a diagnosis of malignant brain tumors, an average of 3.8 years since diagnosis are experiencing greater levels of work limitations than a comparison group. This is consistent with large scale epidemiological research on a homogeneous group of cancer survivors.[3] Also, as expected, almost four years post diagnosis these survivors of a malignant brain tumor had higher levels of fatigue, depressive and anxiety related symptoms, cognitive limitations, and a more negative problem

TABLE 4
Work Characteristics

	Brain Tumor (n = 95)		Non-Cancer Comparison (n = 131)	
	N	%	N	%
Job type				
Managerial/administrative/sales/services	34	35.8	41	31.3
Professional/paraprofessional/technical	41	43.2	64	48.9
Clerical/administrative support/production/ construction/maintenance	12	12.7	9	6.9
Other	8	8.4	17	13.0
Job stress				
Never/seldom	39	41.1	47	35.9
Sometimes	34	35.8	66	50.4
Often	22	23.2	18	13.7
	M	SD	M	SD
Days missed from work for any reason*	19.8	16.8	9.9	9.7
Time at current job (mo)	97.4	98.7	72.9	94.8

*$P < 0.001$.

TABLE 5
Symptom Burden and Problem Solving

	Brain Tumor (n = 95)		Non-Cancer Comparison (n = 131)	
	M	SD	M	SD
MFSI Physical Fatigue *	4.2	4.4	2.4	2.8
HADS Depression*	5.5	4.3	3.1	3.0
HADS Anxiety**	7.4	4.0	6.0	3.4
Cognitive Symptoms Checklist *	22.4	13.3	12.0	9.8
SPSI Neg. Problem Solving Orientation***	2.2	0.9	2.0	0.7

*$P < 0.001$; **$P < 0.01$; ***$P < 0.05$.

TABLE 6
Multivariable Regression of Work Limitations With Cancer Interaction Variables ($n = 226$)

	R	Cumulative R^2	ΔR^2	ΔF	P
Step					
1. Group	0.381	0.145	0.145	38.053	0.000
2. Job-related	0.565	0.320	0.175	14.112	0.000
3. Mood	0.760	0.578	0.258	33.097	0.000
4. Fatigue	0.772	0.596	0.018	4.761	0.009
5. Cognitive limitations	0.796	0.633	0.037	10.586	0.000
6. Health behaviors	0.802	0.643	0.010	1.508	0.201
7. Problem solving	0.807	0.651	0.008	2.213	0.112
Variables	Beta	Partial	t	p	
Group	−0.195	−0.063	−0.910	0.364	
Job-related					
Job stress	0.109	0.105	1.512	0.132	
Group X job stress	−0.013	−0.007	−0.100	0.920	
Time at current job	0.020	0.020	0.292	0.770	
Group X time at current job	−0.070	−0.064	−0.920	0.358	
Mood					
HADS depression*	0.324	0.237	3.503	0.001	
Group X HADS depression	−0.036	−0.026	−0.375	0.708	
HADS anxiety	0.011	0.008	0.119	0.905	
Group X anxiety	0.084	0.043	0.616	0.539	
Fatigue (physical scale)*	0.209	0.206	3.016	0.003	
Group X fatigue	−0.045	−0.045	−0.652	0.515	
Cognitive limitations*	0.222	0.186	2.716	0.007	
Group X cognitive limitations	−0.028	−0.021	−0.306	0.760	
Health behaviors					
Average aerobic activity	−0.079	−0.085	−1.222	0.223	
Group X aerobic activity	0.166	0.083	1.200	0.232	
Enough sleep**	−0.165	−0.150	−2.174	0.031	
Group X enough sleep	0.143	0.118	1.712	0.088	
Negative problem solving orientation**	0.152	0.139	2.016	0.045	
Group X negative problem solving	−0.144	−0.065	−0.938	0.349	

*$P < 0.01$; **$P < 0.05$.

Interaction terms (italics) constructed by multiplying each variable by the cancer status indicator (brain tumor = 0 and non-cancer = 1) and represent the difference in regression coefficients between the brain and non-cancer subgroups.

solving orientation than a non-cancer comparison group. Brain tumor survivors also reported less physical activity and poorer sleep. However, despite this pattern of symptom burden and health behavior difference, the brain tumor survivors did not differ from the comparison group in terms of the association of these factors on work limitations. The same pattern of factors were associated with both brain tumor survivors and the comparison group. Physical fatigue, depressive symptoms, cognitive limitations (ie, composite score including working memory, executive functioning, and attention), sleep, and more negative problem solving were each found to contribute independently to work limitations.

While it is clear that clinical levels of depression in the workplace impact productivity,[29] these findings indicate subsyndromal levels of depression are also related to work productivity. The present findings regarding depressive symptoms have practical implications for both groups. While the total score on the HADS was not at the threshold for clinical depression the scores reflected the presence of some symptoms. With this sub-clinical picture it can be easy to dismiss these symptoms, yet they are strongly associated with work limitations. The use of lower than typical doses of antidepressant medication and/or non-pharmacological approaches may be indicated.[30,31] Given the contribution of depressive symptoms to work limitations, the fact that only 16% of brain tumor cases and 22% of the non-cancer group reported taking medication supports the well established observation that the approaches to enhancing well-being of workers is related to increases in work productivity.[32]

This study also highlights the importance of fatigue,[33] cognitive limitations (working memory, organization, and attention),[34–36] and problem solving orientation on work productivity. Approaches to managing some of these factors in cancer survivors have been recently reviewed[31,37] and while the phenomenology and the biological basis of the fatigue may differ between those exposed to radiation and chemotherapy than non-cancer comparisons,[38] it is not surprising that addressing fatigue should have some impact on productivity in both groups. While employees may not readily disclose these problems in the workplace,[39] it is incumbent on occupational health providers to be vigilant for changes in fatigue, depressive symptoms, sleep problems, and cognitive limitations particularly among cancer survivors, even several years post-diagnosis.[40]

The groups did not differ in regard to type of employment (predominantly professional, technical, or managerial) and both groups are involved in jobs that often require problem solving, coping, and optimal cognitive function. While these jobs are not highly physically demanding, they do require sufficient physical capacity to perform a day's work[41] and it is well known that improving physical capacity, perhaps through exercise, can impact depressive symptoms, fatigue, anxiety, and cognitive limitations in both groups.[42] Cognitive limitations and fatigue justify action in terms of innovative accommodation, exercise, changes in work tasks or work orga-

nization, or perhaps ergonomic and medical management.

This sample was chosen based on current work status. It is not clear how many brain tumor survivors are currently working so we can not comment on the population of current adult brain tumor survivors in the US workplace. However, past studies with smaller samples of brain tumor survivors indicate that between 58%[43] and 73%[44] are working more than two years post-treatment. It can be reasoned that because the participants in this study were currently working, they represent a high functioning cohort of brain tumor survivors. The descriptive data on the brain tumor participants indicated that the types of tumors, the stages of these tumors, and their treatment are consistent with the Surveillance, Epidemiology, and End Results (SEER) data on brain tumors and data in the literature on the pattern of prevalent malignant brain tumors.[45,46] Also, while the data on medical information was obtained through self-report, and not directly from medical records therefore subject to recall bias, recent research suggests that patient recall of information regarding diagnosis and treatment of cancer is related to specific medical record data.[47] Collection of all these data were via an on-line survey. It is important to emphasize that this study was the first to look at brain tumor survivors at work accounting for many of the factors that can impact work productivity. Given the preliminary nature of the investigation it was assumed that the web-based methodology was sufficient.

There were differences in gender, education, and marital status between the brain tumor and non-cancer comparison groups, however, as determined in the preliminary regressions, these were not related to work limitations. Selection bias could have also characterized the non-cancer comparison group although the brain tumor group was higher on all measures of distress and cognitive limitations. The causal relationships of the independent variables on work limitations can not be determined given the cross-sectional nature of this study. The present study used self-report of perceived problems by the worker in the areas of working memory, executive functioning, and attention. Neuropsychological testing is generally considered the "gold standard" for structured measurement of cognitive function.[48] There was no attempt to investigate the relationship between location of tumor and specific cognitive deficits. This was beyond the scope of the current investigation. Lastly, in order to directly link survivor reported cognitive difficulties to actual behavioral deficits at work, future research should employ standardized neuropsychological testing to assess specific deficits in function during the structured evaluation along with patient report and ideally observed measurement of limitations in specific work tasks. New simple and efficient measurement technologies validated against actual behavior in the workplace would be of great benefit to future research efforts.

Occupational function is often merely subsumed in measures of "quality of life" in much research related to cancer survivors.[49] However, a clinical series of brain tumor survivors five years post diagnosis indicated that despite minimal reductions in "quality of life," survivors reported significant impairments in work ability.[50] This series also reported neuropsychological deficits, depression, and anxiety. The present study highlights the importance of evaluating post diagnosis function such as work limitations in contrast to more generic outcomes such as quality of life in order to provide more specific information regarding the association to potentially modifiable factors.

This study should help sensitize health care providers that the symptoms reported by survivors of brain tumors can be related to limitations at work over four years post diagnosis. Many variables such as age, severity of illness, treatment exposure, and medication did not explain observed work limitations at this point in time. A prospective study needs to be completed to describe the trajectory of these relationships over time, but the present results indicate that at four years post diagnosis the association with these types of factors are not present. In contrast, the factors that were related to work limitations are those that are modifiable and attempt to facilitate changes in these factors should be seriously considered. It is simple for providers of all types to ignore these symptoms or health behaviors in cancer survivors when often the focus is on surveillance of the cancer.[51] In the past this had occurred quite often in primary care in primary care setting among survivors of many types of cancers. These symptoms and health behaviors should be attended to if we are to maximize health and well-being.[51] Given the growing number of brain tumor survivors,[52] many will remain in the workplace. Occupational health professionals need to be better equipped with the knowledge and skills to assist them as these symptoms and health behaviors are potentially modifiable and related to work.

Acknowledgment

The authors wish to thank Ben Amick, PhD for his useful suggestions regarding the work limitations measure. Also the authors would like to acknowledge the generous cooperation of the Brain Tumor Society, American Brain Tumor Association, the National Brain Tumor Foundation, and the American Cancer Society Cancer Survivor Network for allowing the authors to post the study on their Websites.

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