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ORIGINAL ARTICLE

Change in 9/11-related post-traumatic stress symptoms following cancer diagnosis

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Abstract

Objective: Cancer can be a life-threatening stressor that may evoke pre-existing post-traumatic stress disorder (PTSD). We assessed change in 9/11-related PTSD symptoms following cancer diagnosis in a 9/11-exposed cohort, the World Trade Center Health Registry.

Methods: We examined enrollees who had a first-time post-9/11 invasive cancer diagnosis and at least one pre- and two post-diagnosis 9/11-related PTSD assessments from enrolment through 2015. PTSD symptoms were measured using 17-item PTSD Checklist (PCL, range 17-85). Cancer was identified from New York State Cancer Registry and categorized as localized or advanced stage. We used piecewise spline linear mixed-effects models to examine rate of change in PCL scores from pre- to post-diagnosis periods, and whether the change differed by gender or stage, with time as fixed and random effects, adjusting for baseline age, race, and education.

Results: 9/11-related PTSD symptoms were slightly increasing in the pre-diagnosis period, while this trend reversed in the post-diagnosis period (β: −0.38; 95% CI: −0.60, −0.15). This trend was driven by male rescue/recovery workers (RRW), among whom significant decrease in rate of change in PCL scores was observed for those with advanced stage (slope change difference [95% CI]: −1.81 [−2.73, −0.90]). No significant difference in rate of change was observed among non-RRW. Among females, PCL scores tended to decrease slightly, with no significant difference in rate of change between pre- and post-diagnosis periods.

Conclusions: We observed significant reduction in the rate of change in 9/11-related PTSD symptoms among male RRW. The underlying mechanism is unknown, necessitating future research.

KEYWORDS
cancer, oncology, post-traumatic stress disorder, world trade center disaster

1 | INTRODUCTION

Post-traumatic stress disorder (PTSD) is a mental disorder that entails clusters of symptoms, including repetitive intrusive thoughts, avoidance, and heightened arousal. Increased PTSD symptoms had been reported among individuals exposed to the September 11, 2001 (9/11) terrorist attack on World Trade Center (WTC) shortly after the exposure and then steadily declined over time.[1-3] The prevalence rates for probable PTSD varied by populations, time of assessment, level of exposure and proximity to the disaster site.[2,3]

Non-traditional responders and community members were also reported to have higher 9/11-related PTSD symptoms than traditional responders.[3] The overall prevalence of 9/11-related probable PTSD symptoms for all responders and non-responders, as defined by PCL-C score ≥44, shifted from 14.3% in 2003–2004 to 19.1% about 5–6 years after the attacks,[1] and returned to 14% in 2015–2016.[2-4]

As the survival time of cancer patients has increased over the past several decades, research that contributes to the understanding of psychiatric and psychosocial morbidity associated with cancer diagnosis and treatment is burgeoning.[5] The pattern of change in 9/11-related PTSD symptoms for those who had a new cancer diagnosis after 9/11 exposure is unknown. Previous studies reported that those with 9/11-related PTSD who experienced subsequent trauma were more likely to re-develop or re-experience 9/11-related PTSD symptoms,[6] or experience PTSD from the subsequent traumatic exposure, such as Hurricane Sandy.[7,8] Unlike Hurricane Sandy, which is another sudden and catastrophic disaster related trauma, cancer experience involves multiple traumatic events over the course of diagnosis and treatment.[9,10] A cancer diagnosis does not necessarily meet the traumatic stressor requirement for Criteria A of PTSD in the revised DSM-V, which considers a life-threatening disease to be responsible for causing PTSD only when the diagnosis is sudden and catastrophic.[11] Though having a history of PTSD could increase the risk of cancer-specific PTSD,[12] whether experiencing a new cancer diagnosis would elicit pre-existing 9/11-related PTSD is unknown.

Stage of cancer indicates disease severity and has been demonstrated to affect cancer-related PTSD symptoms over time, though this body of literature is inconsistent.[9,10,13] While some reported advanced stage was associated cancer-related PTSD, others did not find this relationship.[9,10,13] Given that both a cancer diagnosis and the stage at diagnosis may possibly influence pre-existing PTSD symptomology, it is unknown to what extent these factors could affect 9/11-related PTSD symptomology among those who were exposed to the WTC disaster.

In the present study, we examined change of 9/11-related PTSD symptoms following a first-time cancer diagnosis in a population exposed to the WTC disaster. We hypothesized that 9/11-related PTSD symptoms would increase after cancer diagnosis, and those who were diagnosed at an advanced stage would experience greater increases in 9/11-related PTSD symptoms than those diagnosed at an earlier stage.

2 | METHODS

2.1 | WTCHR and study population

The WTC Health Registry (WTCHR), established in 2002, is the largest post-disaster exposure registry in US history that prospectively follows a cohort who reported exposure to the 9/11 disaster and during its immediate aftermath.[1,14] The Registry has been described in detail elsewhere.[1,14] Briefly, it is a longitudinal cohort of over 71,000 individuals, including rescue/recovery workers and volunteers (RRW) and civilian survivors including residents, students, workers, and passersby on 9/11 in the catchment area in Lower Manhattan (non-RRW). Participants were recruited through area buildings or employer lists or encouraged to enroll via a toll-free telephone number or websites.[14] The enrolment interview (Wave 1, 2003–2004) elicited baseline information about demographics, exposures incurred during and shortly after the WTC disaster, and physical and mental health information. Subsequently, the WTCHR has completed four follow-up surveys (Waves 2, 2006–2007; Wave 3, 2011–2012; Wave 4, 2015–2016, and Wave 5, 2020–2021) via mail, website, or telephone interview, to collect updated information including physical and mental health status. Only data from Wave 1–4 were available and used at the time of this study. For those enrollees with self-reported 9/11-related physical or mental health conditions, WTCHR also makes referrals to one of the Clinical Centers of Excellence that provides 9/11-related physical and mental health services.[15]

The present study sample was selected from the WTCHR cohort, and met the following inclusion criteria: ever been a New York State resident, having a first primary invasive cancer or in situ bladder cancer diagnosed after enrolment, and having had at least one complete 9/11-related PTSD screening measurement prior to, and two complete 9/11-related PTSD Checklist (PCL) measurements following the cancer diagnosis.

This study was approved by the Institutional Review Board (IRB) of the New York City Department of Health and Mental Hygiene. Cancer linkage was approved by New York State Department of Health IRB. A Federal Certificate of Confidentiality was obtained, and oral informed consent was obtained from participants at enrolment.

2.2 | Study variables

9/11-related PTSD symptomology was assessed using the 17-item PCL reported by enrollees at each of the four WTCHR survey waves.[16] The PCL scale items correspond to DSM-IV-TR symptom criteria and were adapted to specifically measure the extent to which an enrollee was bothered by 9/11 event-specific symptoms in the past four weeks. Participants were asked "How much have you been bothered by the following problems in the last 30 days?" for each item and self-rated their severity. Responses include not at all, a little bit, moderately, quite a bit, and extremely, corresponding to score of 1–5, respectively. Responses are summed, with the outcome score ranges from 17 to 85. Past studies have demonstrated adequate diagnostic utility, internal consistency, and test-retest reliability.[17]

This study focuses on first-time invasive cancers including in situ bladder since enrolment that were identified by the New York State Cancer Registry (NYSCR) using Match*Pro. We grouped cancer stage into early or advanced stage based on the summary stage 2000 general coding instruction.[18,19] The 2000 version of Summary Stage applies to every primary site and/or histology combination, using the combined information of derived summary stage 2000, histology, and American Joint Committee on Cancer stage grouping from Collaborative Stage Data Collection System coded fields. Stage 0 (in-situ) and

stage 1 (localized with no lymph node involvement) were defined as early stage. Stages 2–5 (spread to regional lymph nodes, contiguous organs, or both), and stage 7 (distant metastasis) were defined as advanced-stage cancer.

2.3 | Statistical analyses

We performed piecewise linear mixed-effects modeling with random effects and restricted maximum likelihood estimation to examine the change in 9/11-related PCL scores over time. We placed the break-point at the time of cancer diagnosis and derived two time-splines, which represent the rate of change (increase/decrease) in PCL scores per unit time (year in our model) in the pre-diagnosis and post-diagnosis periods. Further, to examine the difference in rate of change in 9/11-related PCL scores between the pre- and post-diagnosis periods, we subtracted the pre-diagnosis slope from the post-diagnosis slope.[20]

To evaluate the effect of cancer stage on the intercept, stage was added as main fixed effects. To evaluate the rate of change in PCL scores in pre- and post-diagnosis periods by cancer stage, interaction terms between stage, time, and time splines were included, with the time and time spline function as random effects and covariates as fixed effects. Since previous studies have shown that PTSD symptomology in response to stressor differs by gender,[21,22] we also ran the models stratified by gender. Baseline covariates were selected a priori following literature review and included age at enrolment, race, education, and gender for analysis involving the full sample, and excluding gender for gender-stratified analyses. Since RRW and non-RRW generally experienced different WTC exposures and each comprised very different socio-demographic characteristics, we also ran stratified models among males by RRW status, and assessed the effect of cancer stage on rate of change in 9/11-related PCL scores, adjusting for the same socio-demographic covariates. All analyses were performed using SAS version 9.4 (SAS Institute Inc.).

3 | RESULTS

Overall, 897 enrollees met the inclusion criteria; median age at diagnosis was 52 (interquartile range: 13). Table 1 includes the descriptive characteristics of the study sample. The majority were between 35 and 64 years of age at enrolment (88.3%), non-Hispanic White (73.1%), and over half (55.1%) completed college or above. Baseline PCL scores were skewed to the right, with 50% having a score less than 27.

Table 2 shows PCL scores change over time for the full study sample and by cancer stage stratified by gender. Overall, there was a significant decrease in the rate of change in PCL scores between pre- and post-diagnosis periods (slope change difference [95% CI]: −0.38 [−0.60, −0.15]), regardless of stage at diagnosis. We observed a significant decrease in the rate of change in PCL scores in the post-diagnosis period compared to the pre-diagnosis period for both early and advanced stages (slope change difference [95% CI]: −0.29 [−0.55, −0.03]; −0.67 [−1.15, −0.18], respectively). The significant changes in PCL scores overall were mainly driven by males. Among males, PCL scores tended to increase in the pre-diagnosis period across all cancer stages, while PCL scores were relatively constant in the post-diagnosis period, or flat, over time. The difference in the slope between pre- and post-diagnosis indicates a statistically significant decrease in the rate of change in PCL scores between pre- and post-diagnosis periods for both stages among males (slope change difference [95% CI]: early: −0.39 [−0.73, −0.06]; advanced: −1.02 [−1.63, −0.40]). Among females, PCL scores tended to decrease slightly, with no significant overall change in slope between the pre- and post-diagnosis periods. No difference in slope was observed by cancer stages between pre- and post-diagnosis periods (Table 2, Figure 1).

Among male RRW, significant decrease in rate of change in PCL scores between pre- and post-diagnosis periods was observed for those with advanced stage (slope change difference [95% CI]: −1.81 [−2.73, −0.90]). No difference in the rate of change in PCL scores by stage was observed between pre- and post-diagnosis periods among non-RRW (Table 3).

TABLE 1 Baseline characteristics and 9/11-related PTSD checklist score of study sample ($N = 897$)

Characteristic	N	%
Age at enrolment		
18–34	36	4.0
35–64	792	88.3
≥65	69	7.7
Median (IQR)	52	(12)
Gender		
Male	523	58.3
Female	374	41.7
Ethnicity		
Non-Hispanic White	656	73.1
Non-Hispanic Black	98	10.9
Hispanic/Latino	80	8.9
Asian	29	3.2
Multiracial	21	2.3
Other/Unknown	13	1.5
Education[a]		
Less than college	400	44.6
Completed college or above	494	55.1
PCL score at enrolment		
Median (IQR)	26	(15)
Mean ± SD	29.7	12.1

Abbreviations: IQR, interquartile range; PCL, PTSD checklist.
[a]Numbers do not add up to total due to missing category.

TABLE 2 Piecewise spline linear mixed effects models for 9/11-related PTSD checklist score change over time with random effects, for all study sample and by stage of cancer, stratified by gender

	Estimated means and 95% confidence interval		
	All sample[a]	Male[b]	Female[b]
Baseline/intercept			
All cancers	30.94 (30.05, 31.83)	29.55 (28.46, 30.64)	32.81 (31.35, 34.26)
Early-stage cancer (in-situ/localized)	32.63 (27.65, 37.60)	37.38 (31.91, 42.86)	38.52 (31.96, 45.07)
Advanced-stage cancer (regional and distant)	33.72 (28.68, 38.77)	38.77 (33.19, 44.35)	38.71 (32.03, 45.39)
Pre-cancer diagnosis period			
All cancers	0.20 (0.03, 0.36)*	0.40 (0.20, 0.61)*	−0.16 (−0.43, 0.11)
Early-stage cancer (in-situ/localized)	0.10 (−0.09, 0.29)	0.28 (0.03, 0.52)*	−0.19 (−0.50, 0.12)
Advanced-stage cancer (regional and distant)	0.52 (0.17, 0.87)*	0.98 (0.54, 1.42)*	−0.16 (−0.72, 0.40)
Post-cancer diagnosis period			
All cancers	−0.18 (−0.28, −0.08)*	−0.09 (−0.22, 0.04)	−0.29 (−0.44, −0.14)*
Early-stage cancer (in-situ/localized)	−0.19 (−0.31, −0.08)*	−0.12 (−0.27, 0.03)	−0.27 (−0.45, −0.10)*
Advanced-stage cancer (regional and distant)	−0.15 (−0.36, 0.07)	−0.04 (−0.32, 0.24)	−0.26 (−0.58, 0.07)
Pre- and post-diagnosis difference			
All cancers	−0.38 (−0.60, −0.15)*	−0.49 (−0.78, −0.21)*	−0.13 (−0.49, 0.24)
Early-stage cancer (in-situ/localized)	−0.29 (−0.55, −0.03)*	−0.39 (−0.73, −0.06)*	−0.09 (−0.51, 0.34)
Advanced-stage cancer (regional and distant)	−0.67 (−1.15, −0.18)*	−1.02 (−1.63, −0.40)*	−0.09 (−0.86, 0.68)

[a]adjusting for baseline age, gender, race and education.

[b]adjusting for baseline age, race and education.

*$P < 0.05$ for significant difference in change in mean PCL score ($p < 0.05$).

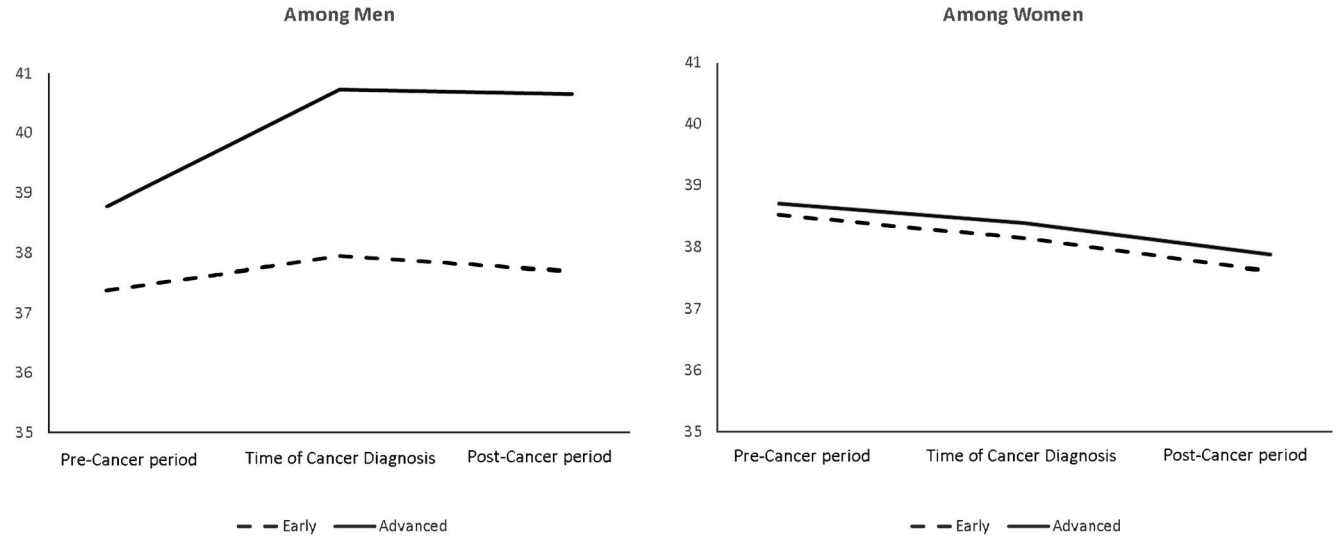

FIGURE 1 Change of 9/11-related PTSD Checklist score between pre- and post-cancer diagnosis periods by gender and stage of cancer

4 | DISCUSSIONS

In the present study, 9/11-related PTSD symptoms were observed to be slightly increasing in the pre-diagnosis period, while this trend reversed in the post-diagnosis period and symptoms started to decrease. This trend was driven largely by males, as PTSD symptoms tended to be decreasing in both the pre- and post-diagnosis periods among females. Additionally, being diagnosed with advanced stage cancer was associated with a greater reduction in 9/11-related PTSD symptoms during the post-diagnosis period among male RRW.

TABLE 3 Change of 9/11-related PTSD Checklist score (co-efficient and 95 CI) over time with random effects, by stage of cancer among male rescue and recovery workers (RRW) and non-RRW

	RRW	Non-RRW
Baseline/intercept		
Early-stage cancer (in-situ/localized)	34.27 (26.36, 42.17)	41.74 (33.93, 49.55)
Advanced-stage cancer (regional and distant)	36.17 (28.26, 44.08)	42.64 (34.39, 50.89)
Pre-cancer diagnosis period		
Early-stage cancer (in-situ/localized)	0.45 (0.09, 0.81)*	−0.01 (−0.31, 0.29)
Advanced-stage cancer (regional and distant)	1.48 (0.82, 2.14)*	0.26 (−0.28, 0.80)
Post-cancer diagnosis period		
Early-stage cancer (in-situ/localized)	0.03 (−0.20, 0.27)	−0.29 (−0.47, −0.11)*
Advanced-stage cancer (regional and distant)	−0.33 (−0.74, 0.08)	0.39 (0.02, 0.76)*
Pre- and post-diagnosis difference		
Early-stage cancer (in-situ/localized)	−0.42 (−0.92, 0.09)	−0.28 (−0.70, 0.13)
Advanced-stage cancer (regional and distant)	−1.81 (−2.73, −0.90)*	0.13 (−0.65, 0.91)

Abbreviation: RRW, rescue/recovery workers.

*Statistically significant different ($p < 0.05$).

4.1 | Access to WTC Health Monitoring Program (WTCHP)

Though the underlying mechanisms for the findings observed in this study are unclear, the significant decline in 9/11-related PTSD symptoms among male RRW in the post-diagnosis period may be due to their resilience to traumatic events and earlier access to medical monitoring and treatment from the WTC Health Monitoring Program (WTCHP), including PTSD-related medical services at no out-of-pocket cost.[23-25] This population was offered extensive care following the 9/11 exposure. Firefighters, including Emergency Medical Services (EMS) workers, received their routine health care services through the department's pre-existing clinical infrastructure. Since September 2001, WTC disaster related physical and mental health monitoring and treatment were implemented to their RRW, which later expanded to include volunteer firefighters and EMS retirees who worked in WTC rescue/recovery effort.[24,25] Additionally, the program established an initiative that provided peer counseling, psychotherapy, and other psychiatric services to help those affected to cope with the challenges related to WTC and early retirement. Other non-firefighting general responders also received medical evaluations since September 2001 through federal funding, and soon after, received physical and mental health treatment through philanthropic funding.[23,24] Both the general responders and firefighters continued to receive federal funding in 2006 to expand coverage for both physical and mental health treatment,[24] since then they were collectively known as the WTCHP. All providers in the program were following similar clinical protocols, with mental health screening provided in the initial visit as part of the overall physical examination to identify persons with mental health problems related to their rescue and recovery roles, and provides referrals to mental health professionals for a full evaluation and follow-up treatment as needed.[23-25] Additionally, with the passing of James Zadroga 9/11 Health and Compensation Act of 2010, WTCHP started to provide standardized monitoring and health care to responders for certified 9/11-related physical and mental health conditions that demonstrated links with WTC-exposure, including cancer.[23] Of the male RRW in this study, 61% reported ever utilizing services provided by the WTCHP, compared to 18% among male non-RRW. Approximately half (51%) of the RRW were uniformed workers (firefighters, police, or sanitation workers), among whom 83% reported ever utilizing services provided by WTCHP (data not shown).

4.2 | Gender

When examining the impact of cancer stage on change in PTSD, differences were observed between males and females. For males, a greater reduction in rate of change in 9/11-related PTSD symptoms from pre- to post-diagnosis periods was observed among those diagnosed at advanced stage, while the rate of change in PTSD symptoms for females was consistent over time regardless of the stage at diagnosis. The gender difference in response to stressors has been shown to be related to gender roles, genetic predisposition, and hormonal influences.[26] Prior literature reports that females are more likely to experience persistent PTSD symptoms after exposure to a traumatic event compared to males.[21,22,27,28] However, the trends observed in this study for females were not significant and cancer stage only influenced PTSD symptoms in males. Further investigation into the drivers behind the rate of change in 9/11-related PTSD symptoms among females is needed.

4.3 | Cancer stage at diagnosis

Our study showed that overall, those who were diagnosed with advanced stage cancers experienced a greater reduction in the rate of change in 911-related PTSD symptoms between pre- and post-diagnosis periods than those who were diagnosed with localized stage cancers. This relationship was mainly driven by males, as the rate of change in PTSD symptoms between pre- and post-diagnosis periods significantly decreased regardless of cancer stage among males only. The mechanism of how stage at cancer diagnosis elicits pre-existing PTSD symptoms is thought to be moderated by subjective appraisal of the threat of disease.[29] Individual characteristics and psychosocial factors such as subjective rating of diagnosis severity may play a larger role than objective measures of disease severity in determining how patients respond to the stress of cancer.[30,31]

4.4 | Post-traumatic growth

The decline in 9/11-related PTSD symptoms in our study sample might be attributed to individuals' concurrent experience with both positive and negative life changes.[32] Positive change and growth have been widely reported for survivors following various traumatic events.[33-35] Several studies have also suggested that Post-traumatic growth (PTG) develops among cancer patients.[30,36,37] While the increase in PTSD symptoms prior to diagnosis in our sample was associated with the WTC disaster, the decreasing trend after diagnosis might be partially due to 9/11-related symptoms subsiding for some patients after experiencing another trauma. In this study, the mean time since cancer diagnosis in the post-diagnosis period ranges from 1.5 to 10 years, with group average median time of 4.6 years (data not shown), which may have given patients time to cope with the stress related to 9/11 and allowed for PTG. Additionally, individuals with traumatic exposures from multiple sources, such as emergency services workers, are more likely to experience PTG,[38] which may be partially responsible for our findings among male RRW.

4.5 | Study limitations

One limitation for this study is that the observed findings in PTSD symptoms were queried relative to the 9/11 disaster, not to the cancer diagnosis. It is possible that the actual cancer-related PTSD symptoms may be manifested differently than our observed findings. Future research focusing specifically on cancer-related PTSD among the 9/11-exposed population would be helpful to delineate the impact of a cancer diagnosis on pre-existing mental health status.

Second, we do not have a 9/11-related PCL measurement at time of cancer diagnosis. We were not able to differentiate the PTSD changes in the period immediately following the cancer diagnosis, a potentially critical time window. A relatively long period after cancer diagnosis may have balanced out the severity or level of PTSD symptoms if it had temporarily increased for a short period of time. We also only had either three or four total time point measures of 9/11-related PCL per subject due to the inclusion criteria that required at least two PCL measurements after cancer diagnosis. Those with cancer diagnosed after Wave 3 account for 85% of those excluded. Another 15% who had cancer diagnosed before Wave three did not come back to take subsequent survey(s) and therefore did not have at least two PCL measures after date of diagnosis for analysis. It was possible that they might have been too ill to participate in the follow-up survey(s) or might have had very short survival times following the diagnosis. However, these cancer patients had similar rates of change in the 9/11-related PCL score as those included in this study (data not shown). Those who remained in our sample were mostly diagnosed with a type of cancer with longer survival (over half had prostate, breast, and skin melanoma).

Previous Registry analyses showed that enrollees with an intermittent survey response were more likely to experience PTSD than those who had completed all waves.[39] The findings included here are for those who had been diagnosed with cancer after the enrolment, survived long enough, and did not drop out, which may result in some level of survival bias. However, for those who met all the inclusion criteria for modeling, the analytical models optimally used all follow-up data available, and sufficiently accounted for unbalanced time points and missing outcomes under the assumption of data missing at random. Further analysis is needed to re-examine the observed pattern when more follow-up survey data become available.

Lastly, the WTCHR cohort at baseline was predominately males, had higher level of education attainment, younger median age, and more non-Hispanic White than the US population at similar period.[40] Therefore, the generalizability of our observed findings to the general population may be limited. However, the analyses in the current study were only limited to those who received their first primary cancer diagnosis after WTC exposure, effectively reducing the bias to the outcome measures.

These limitations are offset by some strengths of this study, including the availability of 9/11-related PTSD measures prior to cancer diagnosis, which allows for the examination of temporal data before and after cancer diagnosis. The piecewise linear mixed-effects models allow us to characterize individual variation relative to the sample mean, while accounting for correlations among repeated measurements taken on the same individual over time by taking into consideration the distance between time of PCL assessment and cancer diagnosis.

4.6 | Clinical implications

This study provided preliminary evidence that first-time invasive cancer with advanced stage is unlikely to evoke or worsen post-9/11 PTSD symptoms among enrollees exposed to the WTC disaster. Given that increased prevalence of 9/11-related PTSD after exposure to the WTC disaster has been well documented among both responders and community members,[1] careful evaluation of pre-cancer mental health history, concurrent psychological suffering

associated with progressive illness, and adjustment following cancer diagnosis and treatment are necessary. Interventions integrating the physical, psychological, social, and spiritual aspects of the total patient for optimal routine care are warranted.

5 | CONCLUSIONS

The changes in 9/11-related PTSD symptomology were different by gender among WTCHR participants who had a first primary cancer diagnosis. Men demonstrated an overall decrease in PTSD symptoms between pre- and post-diagnosis periods in both early and advanced stages, while no changes in PTSD symptoms were observed in women. The observed difference in men was mainly driven by male RRW with advanced stage cancer at diagnosis. Our findings suggest that the subsequent experience of a secondary trauma, cancer, following exposure to 9/11, does not exacerbate 9/11-related PTSD symptoms.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS CONTRIBUTIONS

All authors made substantial contributions to the conception and design of the work; and interpretation of data for the work. Janette Yung conducted data analysis and drafted the manuscript with input from Erin Takemoto, Jiehui Li and James Cone. All authors edited and finalized the manuscript and approved the final manuscript.

ETHICAL APPROVAL STATEMENT

This study was approved by the Institutional Review Board (IRB) of the New York City Department of Health and Mental Hygiene and the IRB # is 07-057. The Institutional Review Boards of the Centers for Disease Control and Prevention approved the WTC Health Registry (WTCHR) study protocol. The main Registry protocol number is #02-058.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author, and with the permission of New York State Cancer Registry (NYSCR). The data are not publicly available due to privacy or ethical restrictions.

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