CAN POSTTRAUMATIC GROWTH PROTECT THE MENTAL AND PHYSICAL HEALTH OF PROSTATE CANCER SURVIVORS?

by

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ABSTRACT

ELIZABETH LANEY ADDINGTON. Can posttraumatic growth protect the mental and physical health of prostate cancer survivors? (Under the direction of DR. RICHARD G. TEDESCHI)

Due to high incidence and survival rates of prostate cancer, mental and physical health outcomes of prostate cancer survivors are important public health issues. Some men with prostate cancer experience positive psychological changes known as posttraumatic growth (PTG), which could operate through psychophysiologic pathways to buffer against negative effects of stress and facilitate health behavior change. However, scant research has tested outcomes of PTG. This longitudinal study therefore examined PTG as a moderator for multiple indicators of mental and physical health in a sample of Black and White prostate cancer survivors (*N*=168) with heterogeneous socioeconomic status. In multivariate analyses, PTG moderated negative effects of initial cancer-related worry on later happiness and mental quality of life, and PTG demonstrated significant, positive main effects on life satisfaction and perceived health. PTG was not significantly related to physical quality of life, cancer-related symptoms, or health behaviors (i.e., exercise, diet, alcohol, sleep). Because this study was not powered to detect small effects, larger samples may reveal additional effects of PTG. Future studies should continue to examine outcomes related to PTG in diverse samples of cancer survivors, using objective measures when possible. In addition, interventions are needed to improve and sustain health behaviors among prostate cancer survivors, many of whom fail to meet recommended levels of physical activity and fruit and vegetable consumption, regardless of their levels of PTG.

DEDICATION

For Tane, LW

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INTRODUCTION

Prostate Cancer

Prostate cancer is the most common cancer among US men (excluding basal and squamous cell skin cancers), with 180,890 new cases expected in 2016 (American Cancer Society, 2016). Although mortality rates from prostate cancer have declined over the past 25 years, it remains the second leading cause of cancer death in US men. Prostate cancer deaths occur primarily among men whose cancer has already metastasized to distant tissue, typically the bones, at the time of diagnosis. In these cases the five-year relative survival rate is only 28%, versus greater than 99% among men diagnosed with locally- or regionally-confined prostate cancer (American Cancer Society, 2016).

Prostate cancer often is asymptomatic when diagnosed, but it can produce urinary or sexual dysfunction in some men (American Cancer Society, 2016). Whether and how to screen for prostate cancer remains controversial, but rising levels of prostate-specific antigen (PSA), a protein produced by the prostate and measured via blood test, can indicate increased risk or progression of prostate cancer (American Cancer Society, 2016, "What you need to know about prostate cancer," 2012). Diagnosis of prostate cancer typically occurs via biopsy, with prostate cancer cells subsequently examined by a pathologist to evaluate the level of cellular abnormality compared to non-cancerous prostate cells; this determines the prostate cancer grade, which is represented as a Gleason score ranging from 2 to 10, with higher scores indicating more abnormal prostate cells that are more likely to grow and spread ("What you need to know about prostate cancer," 2012). Physicians further ascribe a stage to prostate cancer. Based on tests such as PSA, digital rectal exams, and imaging, the stage (typically, I-IV) represents the extent

of cancer – i.e., how much of the prostate is cancerous and how far the cancer has spread beyond the prostate (American Cancer Society, 2016, "What you need to know about prostate cancer," 2012).

Prostate Cancer Treatment

Treatment decisions for prostate cancer are complicated by the inability to reliably predict whether a given tumor will remain indolent or grow more rapidly and metastasize (Cotter, Konety, & Ordonez, 2016). Depending on characteristics of the tumor (e.g., stage, grade) and patient (e.g., life expectancy), common options include radical prostatectomy (surgical removal of the prostate gland), external beam radiation therapy, brachytherapy (radioactive sources implanted in the prostate), and androgen deprivation therapy ("NCCN Clinical Practice Guidelines in Oncology: Prostate Cancer," 2016). Men with advanced or metastatic prostate cancer may benefit most from multimodal treatment, such as combined radiation and hormone therapy (Cotter et al., 2016). Conversely, in men with low or moderately aggressive non-metastatic prostate cancer who also have other comorbid medical conditions, the risk of prostate cancer-specific mortality is quite low (American Cancer Society, 2016; Daskivich et al., 2011). Thus, they may be good candidates for active surveillance, which features regular monitoring of the prostate and deferral of treatment in the absence of disease progression (Chen et al., 2016; Daskivich et al., 2011; "NCCN Clinical Practice Guidelines in Oncology: Prostate Cancer," 2016).

Racial Disparities in Prostate Cancer

Racial disparities in prostate cancer are evident. Black men are 70% more likely than non-Hispanic White men to get prostate cancer and more than twice as likely than

men of any other race/ethnicity to die from prostate cancer (American Cancer Society, 2016). In men with localized prostate cancer, treatment decisions are largely invariant by race (Daskivich, Kwan, Dash, & Litwin, 2015; Xu, Janisse, Ruterbusch, Ager, & Schwartz, 2016). However, in men who originally select active surveillance, White men are more likely than Black men to follow a clear pattern of progression to active treatment (e.g., surgery, radiation, etc.) in accordance with evidence of tumor growth (Xu et al., 2016). At the other end of the cancer spectrum, in men with terminal prostate cancer, cancer-specific tests and treatment (e.g., PSA tests, hormone therapy) are more likely for White men, while aggressive end-of-life measures such as cardiopulmonary resuscitation and admission to the intensive care unit are more likely for Black men (Abdollah et al., 2015).

Biopsychosocial Outcomes in Prostate Cancer Survivors

Cancer Worry

Cancer worry is prevalent in people with prostate or other types of cancer (Fowler, Barry, Lu-Yao, Wasson, & Bin, 1996; Preyde, Hatton-Bauer, Cunningham, & Panjwani, 2012; van den Beuken-van Everdingen et al., 2009), including long-term survivors (Deimling, Bowman, Sterns, Wagner, & Kahana, 2006; Lintz et al., 2003). Common fears are that cancer will metastasize, recur, cause disability or lead to death (Clark, Bokhour, Inui, Silliman, & Talcott, 2003; Holmboe & Concato, 2000; Lintz et al., 2003; van de Wal et al., 2016). The level of cancer worry among men with prostate cancer is often – but not always – related to objective measures of cancer threat, such as cancer stage (Tavlarides et al., 2013). Approximately one-third of prostate cancer survivors experience high levels of cancer worry (van de Wal et al., 2016), which can be

even more bothersome than other psychological concerns such as depression (Preyde et al., 2012). Those with more cancer worry tend to have poorer mental health, more physical symptoms, and lower quality of life (Bellizzi, Latini, Cowan, DuChane, & Carroll, 2008; D'Errico, Galassi, Schanberg, & Ware, 1999; Diefenbach, Mohamed, Horwitz, & Pollack, 2008; van de Wal et al., 2016). However, treatment satisfaction can buffer the negative effects of fear of recurrence on both physical and mental quality of life among prostate cancer survivors (Hart, Latini, Cowan, & Carroll, 2008).

Subjective Well-Being

Despite a call for more research nearly ten years ago (Bloch et al., 2007), psychological adjustment to prostate cancer and especially positive psychological outcomes remain under-studied. In the few exceptions to this trend, positive affect in prostate cancer survivors was positively related to optimism, stress management skills and social support and negatively related to stress (Benedict et al., 2015; Penedo et al., 2003). In a study of older cancer survivors, including men with prostate cancer, compared to age-, gender- and education-matched controls without cancer, life satisfaction did not differ significantly between groups (Zlatar et al., 2015).

Health-Related Quality of Life

A more common outcome of interest in medical populations is health-related quality of life (HRQOL), a multidimensional construct encompassing factors such as functional limitations, mood, energy, and pain, which can influence both mental and physical health (Ware, Kosinski, & Keller, 1995). HRQOL often is examined using an overall score, or by using the mental or physical subtypes. Prostate cancer survivors report poorer HRQOL than demographically matched non-cancer controls and population

norms (Song, Ji, & Nielsen, 2014; Ussher et al., 2016). In most investigations of HRQOL predictors, HRQOL is lower among men with more aggressive (e.g., higher stage) prostate cancer (Jayadevappa, Chhatre, Wein, & Malkowicz, 2009; Lintz et al., 2003; Song et al., 2011). Treatment differences also explain some variation in HRQOL, which has been shown to improve over time in prostatectomy patients and conversely to decline over time in men receiving radiation therapy (Korfage et al., 2005).

While medical factors sometimes lose their significance in multivariate analyses of HRQOL, patient characteristics remain significant predictors of HRQOL among men with prostate cancer (Hu et al., 2004; Potosky et al., 2001). For example, age often is positively associated with global and mental/emotional HRQOL and negatively associated with physical HRQOL (Eton, Lepore, & Helgeson, 2001; Halbert et al., 2010; Hu et al., 2004; Litwin, Lubeck, Spitalny, Henning, & Carroll, 2002; Song et al., 2011). In addition, socioeconomic status tends to positively predict mental, physical, and global HRQOL (Knight et al., 2007; Song et al., 2011).

Overlapping medical, demographic and socioeconomic factors also appear to influence racial disparities in prostate cancer survivors' HRQOL. Although one study found better emotional HRQOL in Black versus White men with prostate cancer (Halbert et al., 2010), most studies report poorer emotional and physical HRQOL among Black compared to White prostate cancer survivors (Eton et al., 2001; Jayadevappa et al., 2009; Jayadevappa, Johnson, Chhatre, Wein, & Malkowicz, 2007; Lubeck et al., 2001). However, race tends to be confounded with other factors; for example, Black participants in prostate cancer research also tend to be younger, have lower socioeconomic status

(SES), higher cancer stage and higher PSA levels than their White counterparts (Lubeck et al., 2001).

Cancer-Specific Symptoms

Prostate cancer and its treatment can produce unwanted side effects that may last for years (Baker, Wellman, & Lavender, 2016; "NCCN Clinical Practice Guidelines in Oncology: Prostate Cancer," 2016). Sexual and urinary dysfunction are common regardless of treatment type, while bowel dysfunction is particular to radiation therapy (Baker et al., 2016; Zelefsky et al., 2016). Hormone therapy often introduces endocrine-related effects including fatigue, weight gain and depression (Baker et al., 2016). Further, treatment side effects are negatively associated with prostate cancer survivors' mental and physical HRQOL (Bellizzi et al., 2008; Buckley, Lapitan, Glazener, & MAPS Trial Group, 2012; Chhatre, Wein, Malkowicz, & Jayadevappa, 2011; Davis et al., 2014; Watson et al., 2016) and may be a barrier to health behaviors such as exercise (Ottenbacher et al., 2013).

Health Behaviors

While research demonstrates increased risk of advanced prostate cancer among men who are overweight/obese, clear evidence that specific health behaviors lower the risk of prostate cancer incidence is lacking ("World Cancer Research Fund International/American Institute for Cancer Research Continuous Update Project Report: Diet, nutrition, physical activity, and prostate cancer," 2014). Nonetheless, cancer survivors' heightened risk of health problems and disability (e.g., late effects of cancer treatment, second cancers, decreased ability to work) can be tempered by improving their health behaviors, particularly smoking cessation, physical activity and diet (Carmack,

Basen-Engquist, & Gritz, 2011). Cancer is therefore considered a "teachable moment," (Demark-Wahnefried, Aziz, Rowland, & Pinto, 2005, p. 5827), but US cancer survivors seem not to seize this opportunity, as most of their health behaviors do not differ significantly from the general population (Mowls, Brame, Martinez, & Beebe, 2016; Ollberding, Maskarinec, Wilkens, Henderson, & Kolonel, 2011). Instead, individuals who are already vulnerable – for instance, those with poor quality of life or low socioeconomic status and Blacks – are at risk of *worsening* their health behaviors (e.g., exercising less) after a cancer diagnosis (Hawkins et al., 2009).

When specifically considering prostate cancer survivors in the US, they are more likely than US men without a history of cancer to engage in regular preventive health care (e.g., cholesterol check, flu immunization), but they are not more likely to engage in other health behaviors such as physical activity or fruit and vegetable consumption (LeMasters, Madhavan, Sambamoorthi, & Kurian, 2014). Comparing survivors of different types of cancer, men with prostate cancer exercise more than breast and colorectal cancer survivors, though they often fail to meet physical activity recommendations (Bluethmann et al., 2015; LeMasters et al., 2014). Moreover, prostate cancer survivors are less likely than women with breast cancer to meet dietary or weight recommendations (LeMasters et al., 2014).

Perceived Health

Perceived health is poorer among prostate cancer survivors who experience poorer mental HRQOL and more cancer-related symptoms such as urinary and sexual problems (Cameron, Springer, Fox-Wasylyshyn, & El-Masri, 2012). Furthermore, it predicts overall and other-cause (i.e., non-prostate cancer) mortality among men with

prostate cancer and is related to demographic and medical factors. Prostate cancer survivors with poorer perceived health were more likely to be older and non-White, to have more comorbidities, and to receive more aggressive prostate cancer treatment (Hoffman et al., 2015).

Posttraumatic Growth

The concept of gain through loss or difficulty has existed for millennia, but scientific research in this area is a relatively new endeavor (Calhoun & Tedeschi, 2006). The primary empirical formulation of this construct is posttraumatic growth (PTG), defined as "positive psychological change experienced as a result of the struggle with highly challenging life circumstances" (Tedeschi & Calhoun, 2004, p. 1). This is typically measured in oncology and other samples by the PTG Inventory (PTGI), comprised of five factors: Personal Strength, (i.e., sense of ability to handle whatever happens in life), New Possibilities (e.g., new opportunities or directions in life), Relating to Others (i.e., improved interpersonal relationships), Spiritual Change (i.e., stronger faith or increased spiritual understanding), and Appreciation of Life (i.e., an increased sense of one's priorities and the value of life) (Steffens & Andrykowski, 2015; Taku, Cann, Calhoun, & Tedeschi, 2008; Tedeschi & Calhoun, 1996).

In addition to the PTGI, the Benefit Finding Scale (Antoni et al., 2001; Tomich & Helgeson, 2004) has been used in several oncology studies. Other quantitative instruments of related constructs include the Changes in Outlook Questionnaire (Joseph et al., 2005; Joseph, Linley, Shevlin, Goodfellow, & Butler, 2006; Joseph, Williams, & Yule, 1993), the Perceived Benefit Scales (McMillen & Fisher, 1998), the Positive Adjustment Questionnaire created specifically for breast cancer survivors (Boot,

Holcombe, & Salmon, 2010), the Silver Lining Questionnaire (McBride, Dunwoody, Lowe-Strong, & Kennedy, 2008; McBride, Schroevers, & Ranchor, 2009; Sodergren & Hyland, 2000), and the Stress-Related Growth Scale (Park, Cohen, & Murch, 1996). These scales assess domains similar to those contained in the PTGI, as well as additional factors such as material gain and responsibility/maturity. Regardless of the measure used, the terms PTG and benefit finding often are treated as if they are interchangeable. Disagreement regarding the distinctiveness of these constructs remains, though in some cases, the relationship between PTG/benefit finding and other variables depends on the measure used (Andrykowski, Steffens, Bush, & Tucker, 2015; Barskova & Oesterreich, 2009; Park & Lechner, 2006; Sears, Stanton, & Danoff-Burg, 2003). Researchers therefore should use caution when interpreting findings from these varying measures (Aspinwall & Tedeschi, 2010a).

PTG occurs when an event is distressing and incongruent with one's beliefs and life narrative, and when one's cognitive and psychosocial responses facilitate rebuilding the worldview and narrative in a way that uncovers new strengths and opportunities (Calhoun, Cann, & Tedeschi, 2010; Stanton, Bower, & Low, 2006; Tedeschi & Calhoun, 2004). Cancer has long been understood as a challenging experience that can compel people to reconsider their beliefs about life and their expectations for the future, thereby serving as a potential catalyst for PTG (Andrykowski & Hunt, 1993; Stanton et al., 2006). Indeed, many survivors of prostate and other cancers experience PTG in the aftermath of their cancer diagnosis and treatment (e.g., Stanton et al., 2006; Wilson, Morris, & Chambers, 2014). Most studies of PTG have focused on its predictors, including demographic, personality, cognitive and social factors such as gender, cancer type,

optimism, core beliefs examination, rumination, and social support (Algoe & Stanton, 2009; Danhauer, Russell, et al., 2013; Kolokotroni, Anagnostopoulos, & Tsikkinis, 2014; Morris & Shakespeare-Finch, 2011; Prati & Pietrantoni, 2009; Stanton et al., 2006; Vishnevsky, Cann, Calhoun, Tedeschi, & Demakis, 2010; Wilson et al., 2014).

The PTG model predicts positive psychosocial outcomes of PTG, and several researchers have suggested potential health benefits (Aspinwall & Tedeschi, 2010b; Bower, Low, Moskowitz, Sepah, & Epel, 2008; Calhoun et al., 2010). However, few have tested PTG outcomes (Algoe & Stanton, 2009). Particularly without this type of substantiating evidence, some have questioned the validity and utility of the PTG construct (e.g., Coyne & Tennen, 2010). This project therefore broadly aims to investigate the relationships between PTG and mental and physical health outcomes among a sample of prostate cancer survivors. Given the high rates of long-term survival in men with prostate cancer (American Cancer Society, 2016), understanding how PTG may influence their lives beyond cancer is important. The review below summarizes the evidence to-date for mental and physical health indicators that may be related to PTG.

Potential Outcomes of PTG

Subjective Well-Being

Evidence for the relationship between PTG and subjective well-being is mixed. Positive affect may be an important factor to consider in medical populations, given its links with physical health (Pressman & Cohen, 2005; Pressman, Gallagher, & Lopez, 2013). However, studies of PTG rarely test its relationship with positive affect, often focusing instead on whether PTG decreases negative affect. The few available reports on PTG and positive affect involve diverse samples: Australian survivors of various traumas

(Barrington & Shakespeare-Finch, 2013), US survivors of colorectal cancer 6-18 months post-diagnosis (Salsman, Segerstrom, Brechting, Carlson, & Andrykowski, 2009), French women 5-15 years after breast cancer diagnosis (Lelorain, Bonnaud-Antignac, & Florin, 2010), and Taiwanese women surveyed multiple times within the first year after surgery for breast cancer (Wang, Chang, Chen, Chen, & Hsu, 2014). The first two studies presented null findings (Barrington & Shakespeare-Finch, 2013; Salsman et al., 2009), while the French study identified a positive relationship between PTG and happiness (Lelorain et al., 2010). In the recent trajectory analysis of Taiwanese women with breast cancer, PTG approximately one year after surgery positively correlated with positive affect measured at the same time, but only for those women whose PTG had increased or remained relatively high since having surgery (Wang et al., 2014). Results for benefit finding are similarly mixed. Benefit finding was positively related to positive affect in Australian colorectal cancer survivors (Rinaldis, Pakenham, & Lynch, 2010), but unrelated to positive affect in American women with breast cancer (Tomich & Helgeson, 2004).

Among Australian trauma survivors, PTG was not significantly related to life satisfaction (Barrington & Shakespeare-Finch, 2013). However, as predicted by the PTG model (Calhoun et al., 2010), others have found that greater PTG is related to higher life satisfaction – among undergraduate students who have experienced a highly stressful event (Cann, Calhoun, Tedeschi, Kilmer, et al., 2010; Triplett, Tedeschi, Cann, Calhoun, & Reeve, 2012), adult survivors of adolescent cancer (Seitz et al., 2011), and long-term breast cancer survivors (Mols, Vingerhoets, Coebergh, & van de Poll-Franse, 2009). Thus, support is not universal for a positive relationship between PTG and psychological

outcomes such as positive affect and life satisfaction, but enough evidence is available to warrant further investigation.

Health-Related Quality of Life

Findings regarding the relationship between PTG and HRQOL have been inconsistent. PTG was not significantly related to overall HRQOL in patients with advanced hepatic cancer (Moore et al., 2011) or in a mixed sample of breast and prostate cancer survivors (Tanyi, Szluha, Nemes, Kovács, & Bugán, 2013). In colorectal cancer survivors approximately five years post-diagnosis, PTG demonstrated only a small correlation (r = .12) with general HRQOL, while benefit finding was unrelated to HRQOL (Jansen, Hoffmeister, Chang-Claude, Brenner, & Arndt, 2011). However, benefit finding positively predicted HRQOL in an earlier sample of colorectal cancer survivors at around one year post-diagnosis (Rinaldis et al., 2010).

A study that administered questionnaires to men with prostate cancer just before surgery reported a negative correlation between PTG and mental HRQOL (Thornton & Perez, 2006). Other investigations of PTG and mental HRQOL have primarily enrolled women with breast cancer. These studies have documented a range of results, including null (Mols et al., 2009; Tanyi et al., 2013), negative (Bellizzi et al., 2010), and positive (Danhauer, Case, et al., 2013; Lelorain et al., 2010; Wang et al., 2014) associations between PTG and mental HRQOL. Research examining PTG and physical HRQOL is similarly inconclusive. Studies enrolling survivors of various cancer types have reported non-significant (Bellizzi et al., 2010; Carboon, Anderson, Pollard, Szer, & Seymour, 2005; Mols et al., 2009; Steel, Gamblin, & Carr, 2008), negative (Tanyi et al., 2013), and

positive associations (Arpawong, Richeimer, Weinstein, Elghamrawy, & Milam, 2013; Jansen et al., 2011).

Given differences in the parameters of studies reporting such disparate findings for the relationship between PTG and HRQOL, researchers have begun to examine potential moderators and mediation pathways. For example, among breast cancer survivors six months to two years post-diagnosis, women demonstrated a positive association between PTG and mental HRQOL if they also denied at least one of the DSM-IV criteria for establishing an event (in this case the breast cancer diagnosis) as a trauma (S. I. M. da Silva, Moreira, & Canavarro, 2011). In another analysis from the same research group, the Personal Strength factor of the PTGI mediated the positive relationship between coping (social support seeking and cognitive factors) and mental HRQOL (S. M. Silva, Crespo, & Canavarro, 2012). Moderation analyses for benefit finding and mental HRQOL have also been conducted; in this case, benefit finding was unrelated to mental HRQOL in women with stage I breast cancer, and it predicted declining mental HRQOL among women with stage II or III cancer (Tomich & Helgeson, 2004).

Cancer-Specific Symptoms

Prostate cancer and its treatment can produce bothersome symptoms, such as urinary, bowel and sexual problems, which often are unremitting or can worsen for many years after diagnosis (Davis et al., 2014; Miller et al., 2005). Measures of these cancer-specific symptoms are associated with both mental and physical HRQOL, but correlations are small to moderate; thus, cancer-specific symptoms and HRQOL are distinct outcomes, and both warrant consideration among prostate cancer survivors (Wei,

Dunn, Litwin, Sandler, & Sanda, 2000). Nonetheless, these symptoms have not yet been included in research on PTG among prostate cancer survivors.

One study of breast cancer survivors identified an inverse relationship between PTG and bothersome side effects of their treatment (Lelorain et al., 2010). Preliminary evidence from HIV research also suggests that PTG may protect against negative physical consequences of illness. In one sample of women with HIV, stress-related growth (again, a construct similar – but not entirely identical – to PTG) moderated the relationship between physical symptoms of the disease and mental health outcomes. Among women with high levels of stress-related growth, physical symptoms were unrelated to depression and predicted only slightly greater anxiety, whereas for women with low levels of growth, having more physical symptoms of HIV was strongly related to higher levels of depression and anxiety (Siegel & Schrimshaw, 2007). Thus, the potential for PTG to protect against bothersome cancer-specific symptoms deserves additional study.

Health Behaviors

Since the PTGI has become a common measure among medical samples, it has been criticized for excluding domains that are particularly relevant to physical health, such as improvements in health behaviors (Park & Lechner, 2006). However, the scale's authors acknowledge that it may not, and in fact, was not intended to evaluate all possible beneficial results of any difficult circumstance (Calhoun & Tedeschi, 2004). PTG does, though, have the potential to inspire or empower cancer survivors to improve their health behaviors; for example, with increases in the PTG domain of appreciation of life, cancer survivors might engage in more health-promoting behaviors as a means of prolonging

their lives (Aspinwall & Tedeschi, 2010b). Preliminary support for this hypothesis comes from a mixed-methods study of survivors of various cancer types, including 15% prostate, in which participants reported the most growth in appreciation of life and also described improvements in their health behaviors such as diet and exercise (Morris, Shakespeare-Finch, & Scott, 2011).

The Health Belief Model provides an additional framework for health behavior changes stemming from PTG (Low et al., 2014). According to this model, people improve their health behaviors when they believe they are susceptible to an illness and perceive themselves as capable of engaging in behaviors that are likely to reduce that risk (Rosenstock, Strecher, & Becker, 1988). While the latter component is typically construed as self-efficacy, it also could be conceived in terms of the personal strength and new possibilities domains of PTG. Indeed, trauma survivors have described increased exercise as a behavioral example of these two PTG domains (Shakespeare-Finch & Barrington, 2012). Thus, cancer survivors who believe they are at risk of cancer progression, disability or recurrence and who also experience PTG might quit smoking, increase their exercise, or improve their diets.

Researchers have tested individual components of this model, but not the hypothesized interaction between cancer worry and PTG. In a study of mixed cancer survivors including nearly one-third prostate survivors, fear of recurrence was positively associated with health behavior improvements (Hawkins et al., 2009). In the only known quantitative test of the relationship between PTG and health behaviors, unmarried female cancer survivors who met guidelines for aerobic and strength exercises also reported higher PTGI scores than those who met only one or neither guideline; however, PTGI

scores did not differ by physical activity for married participants (Crawford, Vallance, Holt, & Courneya, 2014).

Research on conceptually related constructs is similar. Among people with HIV, scores on a modified version of the PTGI were negatively associated with alcohol and drug use (Milam, 2006). In mixed-methods research, adults who underwent bone marrow transplant responded to an open-ended question about finding benefits from cancer; they reported benefits similar to the five PTGI factors, as well as health-related benefits (Tallman, Altmaier, & Garcia, 2007). Among post-treatment cancer survivors, those reporting psychological benefits of cancer (including items similar to those on the PTGI) were more likely to also report participating in physical activity and improving their diet; additional caution is warranted, though, as both outcome measures were single, subjective items (e.g., I have changed my diet to eat more healthy foods) (Low et al., 2014). In thyroid cancer survivors, stress-related growth was positively associated with improvements in health behaviors including exercise, diet, and sleep, but not with use of alcohol or tobacco (Costa & Pakenham, 2012).

Physical Health

The relationship between PTG and physical health remains largely unknown. In a meta-analysis of oncology and HIV/AIDS research, PTG was positively related to perceived health, particularly in studies with more than 25% non-White participants (Sawyer, Ayers, & Field, 2010). The importance of race as a moderator may explain why a study of mostly (87%) White women with breast cancer failed to find a significant relationship between perceived health and either PTG or benefit finding (Sears et al., 2003). Another breast cancer study investigated an idiosyncratic moderator, volunteer

status, and found a significant positive correlation between self-reported health and PTG only among breast cancer survivors who did not volunteer to work with newly diagnosed breast cancer patients (Cohen & Numa, 2011). Interpretation of this result is limited by the cross-sectional nature of the study and significant group differences in perceived health. However, it may support qualitative research suggesting that, for cancer survivors in particular, PTG is closely tied to physical health and compassion toward others (Morris et al., 2011).

Among cancer survivors, psychological factors and health behaviors may influence physical health outcomes through neuroendocrine processes such as glucocorticoid regulation, inflammation and immunity (Antoni et al., 2006; Lutgendorf & Sood, 2011; Powell, Tarr, & Sheridan, 2013). Cancer-related distress can catalyze these processes, as well as the development of PTG. Thus, PTG has the potential to protect physical health by increasing health behaviors or by buffering physiologic effects of stress (Algoe & Stanton, 2009; Aspinwall & Tedeschi, 2010b).

Hypothetically, survivors who experience PTG may exhibit "enhanced allostasis" (Bower et al., 2008). Through psychological benefits of PTG (e.g., recognition of personal strength, improved relationships), events may be perceived as less stressful, or psychosocial responses to challenging events may be more effective. Thus, among individuals with PTG, the physiological stress-response system would be recruited less often and, when activated, could respond more effectively, resulting in less physical wear-and-tear, improved psychoneuroimmunologic functioning, and better physical health (Bower et al., 2008). Much of the research supporting these mechanisms has tested

variables that conceivably are linked to PTG (e.g., self-efficacy, social support), but scant research has tested PTG itself.

A few investigations of non-cancer samples have examined the physiologic effects of PTG. In a laboratory-based study, women who reported higher (vs. lower) levels of PTG from prior life events demonstrated more adaptive cortisol responses to experimental stress tasks, suggesting that PTG may convey physiologic resilience to later stressors (Epel, McEwen, & Ickovics, 1998). A related study found better cortisol recovery in women with greater PTG only if they also reported more daily positive affect (Moskowitz & Epel, 2006). In addition, PTG in survivors of motor vehicle accidents was positively associated with left frontal lobe activation (Rabe, Zöllner, Maercker, & Karl, 2006), further suggesting that PTG may transmit health benefits through neurologic mechanisms of enhanced immunity (Bower et al., 2008).

Preliminary support for the salutary role of PTG in physical health also comes from oncology and other medical samples. In correlational research, PTG was associated with healthier endocrine function (diurnal cortisol slope) in women with breast cancer (Diaz, Aldridge-Gerry, & Spiegel, 2014). Higher PTG also was related to greater immunity (leukocyte counts) in men and women with hepatic cancer and predicted longer survival; on average, those with PTGI scores above the median survived approximately six months longer than those with scores below the median (Dunigan, Carr, & Steel, 2007).

Research using related measures have reported similar findings. For example, benefit finding mediated the relationship between an intervention for breast cancer survivors and decreased cortisol (Cruess et al., 2000), as well as increased immune

function (McGregor et al., 2004). In heart attack survivors, benefit finding was associated with decreased morbidity (Affleck, Tennen, Croog, & Levine, 1987). Among Hispanics with HIV, more growth (measured with a modified version of the PTGI) predicted better immunity (higher CD4 counts) approximately 1.5 years later (Milam, 2006).

PTG as a Buffer

Thus, PTG may serve as a moderator, buffering the negative impact of stress on both mental and physical health outcomes. Moderation analyses predicting subjective well-being have been tested with the PTGI in a single medical sample. In a study of digestive cancer survivors, PTG buffered the relationship between posttraumatic stress symptoms and positive affect such that posttraumatic stress and positive affect were negatively related in participants with low or moderate levels of PTG but unrelated among those with high PTG (Ben-Zur, Cohen, & Gouzman, 2014).

Using perceived benefit instead of PTG, one study of cancer survivors also tested interaction effects on subjective well-being and HRQOL (Park, Chmielewski, & Blank, 2010). Although researchers should be cautious about drawing conclusions about PTG from studies using scales other than the PTGI (Aspinwall & Tedeschi, 2010a), the results may warrant consideration, given the lack of PTGI-specific moderation analyses. In participants with low levels of intrusive thoughts about their cancer, perceived benefit was unrelated to positive affect and life satisfaction. For those with more intrusion, more perceived benefit was associated with more positive affect and life satisfaction. Perceived benefit was not related, through direct effects or interaction, to physical or mental HRQOL (Park et al., 2010).

Three medical studies have tested PTG as a moderator of the relationship between distress and HRQOL. Among cardiovascular patients and women with breast cancer, PTG buffered the harmful effects of posttraumatic stress; having PTG scores above (vs. below) the median attenuated the association between high levels of stress symptoms and poorer mental and overall HRQOL (Bluvstein, Moravchick, Sheps, Schreiber, & Bloch, 2013; Morrill et al., 2008). Similarly, in another study of women with breast cancer, more negative impact of cancer was associated with poorer mental HRQOL among women with low or intermediate levels of PTG; however, for women with high levels of PTG, negative impact of cancer was unrelated to mental HRQOL (S. M. Silva, Moreira, & Canavarro, 2012).

As noted above, models of health behavior also suggest the potential for PTG to contribute to behaviors such as physical activity and diet after a cancer diagnosis. For example, the Theory of Planned Behavior posits that an individual's attitude toward a behavior and perceived behavioral control combine with social norms to predict intentions and behavior (Ajzen, 1991). In addition, the Health Beliefs Model predicts health behaviors based on factors including perceived risk of illness and self-efficacy for practicing the preventive behavior (Rosenstock et al., 1988). While all components of these models were not directly measured in the present study, some of the available variables may serve as proxy measures. For example, cancer worry may represent perceived risk, and it may influence attitudes toward health behaviors (i.e., increase their importance). PTG may facilitate self-efficacy or perceived behavioral control, particularly through the domain of increased personal strength. Thus, the combination of

cancer worry and PTG may especially predict improvements in cancer survivors' health behaviors, but this hypothesis has not been tested.

Aims of the Present Study

Evidence for the relationship between PTG and mental and physical health outcomes is emerging but remains inconclusive. Regarding bivariate relationships, support is strongest for positive associations between PTG and life satisfaction and mental HRQOL, while a diverse body of research preliminarily suggests that PTG may moderate the relationships between health-related problems and mental and physical health outcomes. However, the generalizability of these results, both from cancer and general trauma research, is constrained by the use of predominantly female samples with limited sociodemographic diversity and by varied operationalizations of the posttraumatic growth construct. This study therefore aims to examine associations between PTG and multiple indicators of mental and physical health in a sample of Black and White prostate cancer survivors with heterogeneous socioeconomic status. Specific hypotheses are as follows:

1) PTG moderates the potentially harmful effects of cancer worry on subjective well-being:
    a) Men with low levels of cancer worry will have moderate-high levels of life satisfaction and happiness, regardless of their levels of PTG;
    b) Men with high levels of cancer worry and low levels of PTG will report less life satisfaction and happiness than men with high worry and high PTG.

2) PTG moderates the potentially harmful effects of cancer worry and cancer-specific symptoms:
    a) Men with low levels of cancer worry will have moderate-high levels of HRQOL, regardless of their levels of PTG; men with high levels of cancer worry and low levels of PTG will report poorer HRQOL than men with high worry and high PTG;
    b) The negative relationship between cancer-specific symptoms and HRQOL will be attenuated for men with higher levels of PTG;
    c) Men who report high frequency of cancer-specific symptoms and high PTG will report that their symptoms are less bothersome than men with high frequency of symptoms but low PTG.
3) Men with high levels of cancer worry will be more likely to improve relevant health behaviors if they also have high (rather than low) levels of PTG:
    a) Men with high levels of cancer worry and PTG (as compared to men with low levels of either worry or PTG) will smoke less, exercise more, and have better diets;
    b) Cancer worry and PTG will be unrelated to sleep or alcohol consumption.
4) PTG will attenuate the negative relationship between comorbidity and perceived health.

METHODS

Participants

The North Carolina – Louisiana Prostate Cancer Project (PCaP) was a population-based, observational study of racial differences in prostate cancer. As previously described in more detail ("PCaP snapshot," n.d.; Schroeder et al., 2006), between 2004-2009, PCaP enrolled 1031 newly diagnosed prostate cancer patients from North Carolina (NC) and 1227 from Louisiana. Eligibility criteria included self-reported African American/Black or Caucasian/White race and age 40-79 at the time of prostate cancer diagnosis. Between 2008-2011, NC participants completed up to 3 annual follow-up interviews during the Health Access and Prostate Cancer Treatment in North Carolina (HCaP-NC) study. The current study includes the subset of participants (N=173) who also completed a measure of posttraumatic growth during the final HCaP-NC survey administered in 2011. Institutional Review Boards at all participating institutions approved these procedures.

Measures

Posttraumatic Growth

The short form of the Posttraumatic Growth Inventory (PTGI-SF) is a 10-item questionnaire designed to assess positive changes experienced by individuals after a traumatic or highly stressful event. The PTGI-SF total score has good psychometric properties (Cronbach's $\alpha = .86$ in previous samples; .96 in the current sample) and is an adequate replacement for the total score from the 21-item, original version of the PTGI when survey length requires limitation (Cann, Calhoun, Tedeschi, Taku, et al., 2010). Items assess the same five PTG domains as the original scale: relationships with others,

spirituality, appreciation of life, new possibilities, and personal strength. Items include the stem "Because of my prostate cancer…," adapted for the specific context of this study, and a 6-point Likert response scale ranging from 0 (not at all) to 5 (very great degree). The PTGI-SF was administered during the final follow-up interview with NC participants (time 4, T4), and item scores were averaged to generate the PTGI-SF scale score, with higher scores indicating a greater degree of positive changes occurring due to the prostate cancer experience.

Cancer Worry

Cancer worry was measured during the initial PCaP interview (time 1, T1) using four items adapted from a study that examined the risks and other factors men consider when deciding on treatment for prostate cancer (Holmboe & Concato, 2000). These items assessed participants' level of concern about metastasis, becoming dependent on others due to cancer, and dying from cancer, as well as their perceived likelihood of dying from cancer. Each item was rated on a scale from 1 (not) to 5 (extremely). Item scores were averaged to generate a scale score, with higher scores indicating more cancer-related worry. Internal consistency was good (Cronbach's $\alpha = .84$).

Subjective Well-Being

Two indicators of subjective well-being were measured during HCaP-NC follow-up interviews at time 2 (T2) and T4; at both time points, participants were instructed to complete these measures based on their current experiences. One item, on a scale ranging from one to ten, assessed how happy participants usually are (Fordyce, 1988). Life satisfaction was assessed using the Satisfaction with Life Scale, a five-item measure of global life satisfaction (Diener, Emmons, Larsen, & Griffin, 1985). The scale ranges from

1 (strongly disagree) to 5 (strongly agree) and includes items such as "In most ways my life is close to ideal." Internal consistency in this sample was good to excellent (Cronbach's α = .89 at T2, .90 at T4).

Mental and Physical HRQOL

The Short Form 12 (SF-12) General Health Survey, version 2, is a 12-item measure that was designed to detect group differences in HRQOL among chronic health patients participating in longitudinal research; it provides summary scores for both mental and physical HRQOL that range from 0 to 100, with higher scores indicating better HRQOL (Ware et al., 1995). Based on a review of psychometric properties of scales commonly used in prostate cancer research, the SF-12 is the most highly recommended instrument for measuring HRQOL in men with prostate cancer (Hamoen, De Rooij, Witjes, Barentsz, & Rovers, 2015). The mental and physical summary scores from the initial PCaP interview (T1) and from the final HCaP-NC follow-up interview (T4) were used for the purposes of the present study. According to the standard administration of the SF-12, items reference either participants' current experience (e.g., Does your health now limit you in moderate activities…?) or their experience and activities over the past 4 weeks (e.g., During the past 4 weeks, how much of the time have you accomplished less than you would like as a result of your physical health? How much of the time during the past 4 weeks have you felt downhearted and depressed?).

Cancer-Specific Symptoms

The abbreviated version of the Expanded Prostate Cancer Index Composite (EPIC-26) assessed function and bother in urinary, bowel, sexual and hormonal domains. For example, items assess the frequency of symptoms such as urinary leaking and ask

participants to rate how problematic these symptoms are. EPIC-26 has been validated in long-term (≥4 years) prostate cancer survivors who received a variety of treatments, demonstrating acceptable internal consistency (Cronbach's $\alpha \geq .70$) and test-retest reliability ($r \geq .69$) in the original validation samples (Miller et al., 2005; Szymanski, Wei, Dunn, & Sanda, 2010). Based on standardized evaluation of patient-reported outcomes, EPIC-26 is the most highly recommended measure of prostate cancer-specific symptom outcomes (Schmidt et al., 2014). Understanding the relationship between frequency of cancer-specific symptoms (function) and how troublesome they are (bother) can provide a clearer view of survivors' experience; thus, while these measures may be combined for efficiency, research also supports their separate consideration (Reeve, Potosky, & Willis, 2006). EPIC-26 scores from the initial HCaP-NC interview (T2, the first administration of this measure) and the final HCaP-NC follow-up interview (T4) were used for the purposes of the present study. In the current sample, internal consistency of the total score and subscales was acceptable to good (EPIC total: Cronbach's $\alpha = .86$ at T2, .85 at T4; EPIC function: Cronbach's $\alpha = .75$ at T2, .76 at T4; EPIC bother: .86 at T2, .88 at T4). EPIC-26 is scored such that higher scores indicate better prostate cancer-specific well-being (i.e., lower frequency of symptoms and less symptom-related bother).

Health Behaviors

Physical activity was assessed with a six-item questionnaire designed to minimize participant burden while obtaining data valid for medical research; the survey assesses aerobic activity and strength training, allowing for computation of metabolic equivalent task (MET) minutes (Littman et al., 2004). For example, equivalencies for each minute of

activity are as follows: 1.1 for light activity, 3.0 for moderate activity and 6.0 for vigorous activity ("2008 Physical activity guidelines for Americans," 2008). At T1, participants were asked to report on their physical activity during the year prior to prostate cancer diagnosis. At T4, they reported on their physical activity over the past 12 months.

Consumption of fruit, vegetables and alcohol were assessed with items from the National Cancer Institute food frequency questionnaire (Subar et al., 1995, 2000). At T1, participants reported their consumption of these items during the year prior to prostate cancer diagnosis. At T4, they reported their current levels of consumption. Fruit and vegetable consumption were reported in two separate items, both of which used the following response options: less than 1 time/week, 1-2 times/week, 3-4 times/week, 5-6 times/week, once a day, 2 times/day, 3 times/day, 4 times/day or 5 or more times/day. Each participant's use was subsequently categorized and coded as 1 for men who eat fruit and/or vegetables at least once per day and 0 for those who do not. Frequency and amount of alcohol consumption were measured at T1 and T4 with separate items for beer, wine or wine coolers, and liquor (e.g., "How often do you drink beer? If you drink beer, how much do you usually drink?"). Total weekly alcohol consumption was calculated by multiplying frequency and amount for each alcohol type, followed by summing the three weekly amounts (i.e., estimated number of beers/week + glasses of wine or wine coolers/week + number of shots of liquor/week). Current smoking was assessed with the question "Do you still smoke cigarettes?" at T1 and "Do you smoke cigarettes at least once a day now?" at T4 (no = 0, yes = 1).

At T2 and T4, participants' current amount of sleep per day was measured using an item from the National Health Interview Survey from the Centers for Disease Control and Prevention ("NHIS - About the National Health Interview Survey," n.d.). Response options included <5 hours, 5-6 hours, 7-8 hours, or 9 or more hours, which were recoded as a measure of whether or not each participant's daily sleep amount meets current health recommendations (1 = yes: 7-8 hours; 0 = no: all other amounts) ("How Much Sleep Is Enough? - NHLBI, NIH," 2012).

Perceived Health

Perceived health was measured at T1 and T4 with a single self-reported item asking, "In general, would you say your health is…," with a response scale ranging from 1 ("excellent") to 5 ("poor"). It has been used in prior cancer research and is related to mortality among men with prostate cancer (Hoffman et al., 2015; Sears et al., 2003).

Potential Covariates

During the initial PCaP interview (T1), participants provided a self-report of potential sociodemographic covariates, including date of birth, race (Caucasian American/White: 0, African American/Black: 1), marital status (separated, divorced, widowed, or never married: 0; married or living as married: 1), education [≤high school (HS): 0, >HS: 1], and employment status (retired, unemployed, or disabled: 0; employed full- or part-time: 1). Income was self-reported with two items: (a) category of household income (ranging from <$5000 to >$80,000); and (b) number of people supported by that income. Income per person was calculated as the midpoint of the household income category (using $85,000 for the maximum category), divided by the number of people supported by that income.

During the initial PCaP interview (T1), participants additionally completed the Rapid Estimate of Adult Literacy in Medicine (REALM), a screening measure for low literacy in medical contexts (Murphy, Davis, Long, Jackson, & Decker, 1993). Respondents read a list of 66 health-related words, arranged in order of increasing difficulty. The number of correctly pronounced words was summed to provide the REALM raw score (range 0-66), which was then converted to a grade-level equivalent and categorized as <HS or HS (coded as 0 or 1, respectively).

Participants self-reported their family history of prostate cancer and their comorbid medical conditions, including their personal history of any additional cancer other than prostate, during the initial PCaP interview (T1). The list of health conditions each participant endorsed was used to derive the Charlson comorbidity index (CCI; categorized as 0, $\geq$1), which represents increasing relative risk of dying within 1 year. In the original research development of the measure, participants with CCI of 0 had a 12% risk of dying within 1 year, while the risk for participants with CCI of 1 or greater was at least 26% (Charlson, Pompei, Ales, & MacKenzie, 1987).

Other medical covariates were abstracted from medical records released from participants' diagnosing and/or treating physician(s). These include date of diagnosis, measures of cancer severity at the time of diagnosis [e.g., cancer stage, Gleason score, prostate-specific antigen (PSA)], and details of cancer treatment. Based on the following algorithm, prostate cancer aggressiveness was categorized as: (a) low for participants with Gleason score <7, stage T1-T2, and PSA<10ng/ml; (b) high when Gleason score $\geq$8, or PSA>20ng/ml, or Gleason score=7 and stage T3-T4; and (c) intermediate for all other cases (Schroeder et al., 2006). Major categories of prostate cancer treatment [radical

prostatectomy, radiation therapy, hormone therapy, other] were categorized as no or yes (coded as 0 or 1, respectively), and the total number of treatments received was summed for each participant. Age at diagnosis and time since diagnosis were calculated from diagnosis date and birthdate or date of survey administration, respectively.

Data Analysis

Missing Data

The original data set included 173 prostate cancer survivors from North Carolina who completed the final HCaP-NC follow-up interview in 2011. Five cases without PTG data were excluded from analysis, leaving 168 cases. None of the 168 cases were missing data on the predictor variables for any of the hypotheses. Cases that were missing data on the outcome variable for each hypothesis were omitted only from the analysis of that particular hypothesis (hypothesis 1: n=2 missing happiness; hypotheses 2a and 2b: n=3 missing HRQOL; hypothesis 3a: n=1 missing vegetable consumption, n=8 missing physical activity).

For covariates with missing data, hot deck imputation was used to avoid the potential bias and loss of power that can occur with listwise deletion (see Myers, 2011 for a review). When applying hot deck imputation, missing data on a particular variable are imputed from cases with the same values on other variables that are a) associated with the variable being imputed but b) peripheral to the theory or hypothesis being tested (Myers, 2011). For example, missing income data were imputed from cases who shared the same race, level of education, and employment status. Variables with missing data imputed according to this method included income (n=8), cancer stage (n=2), total number of cancer treatment types received (n=4), prostatectomy (n=3), radiation (n=2), androgen

deprivation therapy (*n*=2), and other types of treatment (*n*=4). Outcome variables (i.e., subjective well-being, HRQOL, cancer-specific symptoms, health behaviors, perceived health) did not differ significantly between participants with complete data vs. those treated with hot deck imputation. Thus, cases with imputed data on covariates were retained.

Analyses

Power analyses were conducted using G*Power version 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009; Faul, Erdfelder, Lang, & Buchner, 2007). All other analyses were conducted in SPSS version 21. Descriptive statistics were used to characterize the sample. Outcome variables were examined for normality, with absolute values of skewness less than 2 indicating reasonably normal outcome data (Pituch & Stevens, 2016). Outcome variables that were significantly skewed were log transformed and then re-evaluated for normality prior to conducting additional analyses. Bivariate analyses were performed to determine the covariates of each outcome variable, using parametric tests (i.e., Pearson's correlation for continuous variables, independent *t*-test for categorical variables with 2 values, and ANOVA for categorical variables with >2 values) for normally distributed or log-transformed outcomes. Covariates that were significantly associated with the outcome variable in bivariate analyses (at $p < .05$) were examined for multicollinearity, as indicated by variance inflation factor greater than 10 or tolerance below .10 (Pituch & Stevens, 2016). Prior to testing each of the final models, cases were temporarily omitted if they were identified as multivariate outliers by graphing and by leverage score greater than $3K/N$ (where K = number of predictor variables).

Given that each hypothesis predicted moderation by PTG, interaction terms were included in each of the multiple regression analyses. Predictor and moderator variables therefore were mean-centered prior to multivariate analysis to eliminate multicollinearity between the interaction term and each of its constituent first-order terms. For consistency in interpretation of results, continuous covariates also were mean-centered. Subsequently, each hypothesis was tested using the PROCESS approach, which automatically conducts logistic regression when the outcome variable is categorical rather than continuous (Hayes, 2013).

RESULTS

Sample Characteristics

As shown in Table 1, 168 prostate cancer survivors (42% Black, 58% White) participated in the current study. Most (78%) were married or living as married. A significant proportion (35%) obtained, at most, a high school education. Just over half (56%) were employed full- or part-time. Mean annual income per person was approximately $29,000 but varied widely.

Mean age at diagnosis was approximately 61 years old. Measures were administered, on average, 5.5 months post-diagnosis at time 1 and 5.2 years post-diagnosis at time 4. The vast majority of the sample was diagnosed with cancer at Gleason score 7 or lower (98%) and stage T1-T2 (99%). A small percentage (11%) elected not to undergo any active treatment, while approximately half (51%) underwent one active treatment, the most common of which was prostatectomy (71%).

Descriptive statistics and correlations between variables of primary interest are shown in Table 2. On average, cancer worry at T1 was relatively low in this sample (M = 2.03 on scale of 1-5), while PTG levels were moderate (M = 2.75 on scale of 0-5; item response 3 indicates “a moderate degree” of change experienced due to cancer). Cancer worry and PTG were significantly positively related. Cancer worry also was significantly negatively correlated with T4 mental and physical HRQOL, both of which were, on average, near the midpoint of the scale (i.e., 50). PTG significantly positively correlated with life satisfaction at T4, but none of the other outcome variables.

Hypothesis 1

Hypothesis 1 predicted that PTG would buffer the negative effect of cancer worry on subjective well-being, which was measured separately as happiness and life satisfaction. Both outcome variables were relatively normally distributed. Thus, additional analyses were conducted using parametric tests without transforming either happiness or life satisfaction at T4.

Happiness

On average, happiness at T2 (M = 7.72, SD = 1.64) was equivalent to happiness at T4, approximately 5 years post-diagnosis (M = 7.84, SD = 1.70), $t(162) = -.96$, $p = .34$. Most participants reported an increase (1-point increase: n = 38, 23.3%; $\geq$2 point increase: n = 24, 14.7%) or unchanged happiness over time (n = 54, 33.1%), while the remainder reported a decrease in happiness (1-point decrease: n = 29, 17.8%; $\geq$2 point decrease: n = 18, 11.0%). No participants reported a change in happiness of more than 6 points on this 10-point measure.

As noted in Table 2, happiness at T4 (n=166) was not significantly correlated with baseline cancer worry or with PTG. In additional bivariate analyses, baseline mental HRQOL (r = .33, $p < .001$) and prior levels of happiness (r = .57, $p < .001$) and life satisfaction (r = .55, $p < .001$) were identified as significant covariates of the outcome variable. None of the sociodemographic or medical variables significantly correlated with happiness at T4 (all p's > .05).

Upon examining graphs and leverage scores, four cases were identified as multivariate outliers and temporarily omitted, leaving N=162 in tests of the final model for this hypothesis. According to G*Power, in a regression model with 6 predictors (3

covariates, predictor, moderator and interaction term), *N*=146 is required for 95% power to detect a medium effect in the omnibus test of this multiple regression, while *N*=688 is required for 80% power to detect a small effect. Regarding the power for detecting effects related to the change in R^2, *N*=89 is required for 95% power to detect a medium effect, while *N*=395 is required for 80% power to detect a small effect. Tests of Hypothesis 1 modeling happiness as the outcome variable therefore had excellent power to detect medium or large effects sizes, but lacked power to detect small effects.

In multivariate analyses, the full model was significant, $F(6, 155) = 17.63$, $p < .001$, and explained 41% of the variance in T4 happiness. As shown in Table 3, baseline mental HRQOL was non-significant, but prior levels of life satisfaction and happiness positively predicted later happiness. In addition, the interaction was significant and contributed to a 2% increase in R^2 ($p = .026$). Probing the interaction revealed a significant negative effect of cancer worry on T4 happiness only at low levels of PTG, while cancer worry was unrelated to happiness among individuals with mean or higher levels of PTG (see Table 3 and Figure 1).

Life Satisfaction

Life satisfaction at T4, approximately 5 years post-diagnosis ($M = 3.83$, $SD = .86$) trended towards being significantly higher, on average, than life satisfaction at T2 ($M = 3.71$, $SD = .96$), $t(166) = -1.97$, $p = .051$. Nearly a third of participants ($n = 53$, 31.7%) reported a decline in life satisfaction over time, approximately half ($n = 81$, 48.5%) reported an increase, and the remainder ($n = 33$, 19.8%) reported no change. No participants reported a change in life satisfaction of more than 3 points.

As noted in Table 2, life satisfaction at T4 (n=168) was significantly positively related to PTG but unrelated to baseline cancer worry. In additional bivariate analyses, baseline mental HRQOL (r = .38, p < .001) and prior levels of happiness (r = .54, p < .001) and life satisfaction (r = .62, p < .001) were identified as significant covariates of the outcome variable. Moreover, life satisfaction at T4 was significantly higher among White (M = 3.96, SD = .81) than Black (M = 3.61, SD = .91) men, t(166) = 2.59, p = .01, men with greater income (r = .22, p = .006), and men who were older when diagnosed with prostate cancer (r = .25, p = .001). Other sociodemographic and medical variables were unrelated to life satisfaction at T4 (all p's > .05).

Using graphs and leverage scores, two cases were identified as multivariate outliers and temporarily omitted, leaving N=162 in tests of the final model for this hypothesis. According to G*Power, in a regression model with 9 predictors (6 covariates, predictor, moderator and interaction term), N=141 is required for 90% power to detect a medium effect in the omnibus test of this multiple regression, while N=791 is required for 80% power to detect a small effect. Regarding the power for detecting effects related to the change in R^2, N=89 is required for 95% power to detect a medium effect, while N=528 is required for 80% power to detect a small effect. Tests of Hypothesis 1 modeling life satisfaction as the outcome variable therefore were well-powered to detect medium or large effects sizes, but lacked power to detect small effects.

In multivariate analyses, the full model was significant, F(9, 152) = 15.49, p < .001, and explained 48% of the variance in T4 life satisfaction. As shown in Table 4, prior life satisfaction and happiness, as well as PTG positively predicted life satisfaction at T4, while other covariates became non-significant. Moreover, the interaction was not

significant and did not contribute to an increase in variance explained [change in R^2 = .004, $F(1, 152) = 1.13$, $p = .29$]. Thus, hypothesis 1 was only partially supported.

Hypothesis 2

Hypothesis 2 predicted that PTG would buffer negative effects of cancer worry and cancer-specific symptoms on HRQOL and symptom-related bother. Because the outcome variables were relatively normally distributed, additional analyses were conducted using parametric tests without transforming mental HRQOL, physical HRQOL or symptom-related bother (EPIC-bother) at T4. As shown in Table 2, mental and physical HRQOL at T4 were unrelated. However, cancer-related symptoms were significantly related to both mental and physical HRQOL, such that men who reported greater frequency of symptoms or symptom-related bother tended to have poorer mental and physical HRQOL.

Mental HRQOL

Bivariate analyses to determine covariates of mental HRQOL for the test of Hypothesis 2 revealed significant results for age at diagnosis ($r = .19$, $p = .014$) and for baseline mental HRQOL and well-being (mental HRQOL at T1: $r = .44$, $p < .001$; life satisfaction at T2: $r = .40$, $p < .001$; happiness at T2: $r = .54$, $p < .001$). Mental HRQOL tended to be higher among prostate cancer survivors who were older and who previously had better psychological well-being and HRQOL. None of the medical variables or the other sociodemographic indicators was significantly related to mental HRQOL at T4 (all p's > .05).

Upon examining graphs and leverage scores, three cases were identified as multivariate outliers and temporarily omitted, leaving N=158 in tests of the final model of

Hypothesis 2 predicting mental HRQOL at T4. According to G*Power, in a regression model with 9 predictors (4 covariates, 2 predictors, a moderator and 2 interaction terms), *N*=141 is required for 90% power to detect a medium effect in the omnibus test of this multiple regression, while *N*=791 is required for 80% power to detect a small effect. Regarding the power for detecting effects related to the change in R^2, *N*=107 is required for 95% power to detect a medium effect, while *N*=485 is required for 80% power to detect a small effect. The analysis of Hypothesis 2 predicting mental HRQOL therefore had sufficient power to detect medium or large effects sizes, but not small effects.

In multivariate analyses, the full model was significant, $F(9, 148) = 8.55$, $p < .001$, and explained 34% of the variance in T4 mental HRQOL. As shown in Table 5, most covariates were non-significant in the final model, though baseline mental HRQOL and happiness retained their significance. Hypothesis 2 was partially supported. The addition of the interaction terms did not significantly contribute to the variance in T4 mental HRQOL (change in $R^2 = .02$, $p = .10$), and the interaction between PTG and cancer-related symptoms was not significant. However, the interaction between PTG and cancer worry was significant. Probing the cancer worry x PTG interaction did not reveal any significant conditional effects of cancer worry on T4 mental HRQOL, but the conditional effect of cancer worry at levels of PTG one standard deviation below the mean trended toward significance ($p = .07$). This indicates that cancer worry at the time of diagnosis may negatively influence mental HRQOL at five years post-diagnosis among men who experience extremely low levels of PTG (see Table 5 and Figure 2).

Physical HRQOL

Bivariate analyses revealed numerous covariates of physical HRQOL at T4. Sociodemographic covariates included race (White: M = 48.22, SD = 10.47; Black: M = 43.75, SD = 10.64; $t(163) = 2.68$, $p = .008$), education ($\leq$HS: M = 41.60, SD = 11.57; >HS: M = 48.86, SD = 9.40; $t(163) = 4.34$, $p < .001$), medical literacy (<HS: M = 40.58, SD = 11.93; HS: M = 48.45, SD = 9.49; $t(64) = 3.95$, $p < .001$), employment status (employed: M = 49.25, SD = 9.48; not employed: M = 42.61, SD = 11.17; $t(163) = 4.12$, $p < .001$), income ($r = .28$, $p < .001$), and age at diagnosis ($r = -.20$, $p = .009$). Medical covariates included comorbidity (CCI=0: M = 49.18, SD = 9.31; CCI$\geq$1: M = 41.53, SD = 11.35; $t(163) = 4.69$, $p < .001$), PSA ($r = -.17$, $p = .031$), cancer stage (T1: M = 46.71, SD = 10.84; T2-4: M = 45.41, SD = 10.67; $t(161) = .71$, $p = .048$), and receipt of treatment other than prostatectomy, radiation or androgen deprivation therapy (i.e., watchful waiting, clinical trial, etc.; yes: M = 49.72, SD = 7.99; no: M = 45.78, SD = 11.06; $t(40) = 2.10$, $p = .042$). Also significant were baseline levels of both physical ($r = .49$, $p < .001$) and mental HRQOL ($r = .18$, $p = .02$), life satisfaction ($r = .21$, $p = .008$) and happiness ($r = .26$, $p = .001$). Despite the large number of covariates, multicollinearity statistics were adequate (i.e., tolerance > .1 and variance inflation factor < 10) to proceed without correction (e.g., principal components analysis), particularly given the sample size, N < 200 (Pituch & Stevens, 2016).

Upon examining graphs and leverage scores, one case was identified as a multivariate outlier and temporarily omitted, leaving N=160 in tests of the final model of Hypothesis 2 predicting physical HRQOL at T4. According to G*Power, in a regression model with 19 predictors (14 covariates, 2 predictors, a moderator and 2 interaction

terms), N=153 is required for 80% power to detect a medium effect in the omnibus test of this multiple regression, while N=1043 is required for 80% power to detect a small effect. Regarding the power for detecting effects related to the change in R^2, N=107 is required for 95% power to detect a medium effect, while N=485 is required for 80% power to detect a small effect. Thus, the analysis of Hypothesis 2 predicting physical HRQOL had adequate power to detect medium or large effects sizes, but not small effects.

The full multivariate model was significant, $F(19, 140) = 7.54$, $p < .001$, and explained 51% of the variance in T4 physical HRQOL. As shown in Table 6, several sociodemographic (age, medical literacy) and medical covariates (comorbidity, PSA, receipt of other treatment) remained significant in multivariate analyses, as did baseline physical HRQOL and happiness. Contrary to Hypothesis 2, the interaction terms were not significant and did not significantly contribute to the variance in T4 physical HRQOL (change in $R^2 = .002$, $p = .80$), nor did cancer worry, cancer-specific symptoms or PTG have a significant direct effect.

Symptom-Related Bother

When examining symptom-related bother (EPIC-Bother) as the outcome at T4, bivariate analyses revealed significant relationships with frequency of cancer-specific symptoms (EPIC-Function) at T4 ($r = .40$, $p < .001$), EPIC-Bother at T2 ($r = .58$, $p < .001$), T4 HRQOL and well-being (mental HRQOL: $r = .48$, $p < .001$; physical HRQOL: $r = .40$, $p < .001$; life satisfaction: $r = .25$, $p < .001$; happiness: $r = .29$, $p < .001$). Sociodemographic and medical covariates included income ($r = .16$, $p = .039$), employment status, $t(113) = 2.14$, $p = .035$ (employed: $M = 87.79$, $SD = 10.07$; not

employed: M = 83.04, SD = 16.90), and comorbidity, $t(116) = 2.80$, $p = .006$ (CCI=0: M = 87.92, SD = 14.13; CCI≥1: M = 81.91, SD = 12.03).

Upon examining graphs and leverage scores, three cases were identified as multivariate outliers and temporarily omitted, leaving N=160 in tests of the final model predicted cancer-related symptom bother at T4. According to G*Power, in a regression model with 11 predictors (8 covariates, predictor, moderator and interaction term), N=152 is required for 90% power to detect a medium effect in the omnibus test of this multiple regression, while N=850 is required for 80% power to detect a small effect. Regarding the power for detecting effects related to the change in R^2, N=89 is required for 95% power to detect a medium effect, while N=395 is required for 80% power to detect a small effect. This analysis therefore had power to detect only medium or large effects in the omnibus test or the change in R^2.

The full multivariate model was significant, $F(11, 148) = 13.26$, $p < .001$, and explained 50% of the variance in T4 cancer-related symptom bother. As shown in Table 7, sociodemographic factors, medical covariates, and subjective well-being did not retain their significance. PTG and the interaction term also were non-significant; the latter did not contribute to the variance in the outcome (change in $R^2 = .001$, $p = .68$). Only cancer-specific symptom frequency, baseline levels of symptom-related bother, and HRQOL (both physical and mental) significantly predicted T4 cancer-related symptom bother. Hypothesis 2c therefore was not supported.

Hypothesis 3

Hypothesis 3 predicted that prostate cancer survivors with high levels of cancer worry would be more likely to improve relevant health behaviors – smoking, physical

activity, and fruit and vegetable consumption – if they also had high (rather than low) levels of PTG, whereas cancer worry and PTG would be unrelated to alcohol consumption and sleep. Preliminary analyses revealed that only 18 participants (10.7%) were current smokers at the time of the baseline interview, approximately 6 months post-diagnosis. Due to the limited sample size, multivariate analysis of predictors of smoking cessation was omitted.

Physical Activity

Preliminary analyses revealed that physical activity at T4 was relatively normally distributed. Physical activity prior to diagnosis ranged from 0 to 4611 MET minutes/week, with 73% of the sample obtaining 500 or more MET minutes/week. At T4, physical activity similarly ranged from 0 to 4698 MET minutes/week, but the proportion obtaining at least 500 MET minutes/week fell to 55%. Weekly MET minutes decreased over five years post-diagnosis for 62% of the sample, and the mean at T4 (M = 873.74, SD = 817.67) was significantly lower than at baseline (M = 1202.59, SD = 909.84), $t(160) = 4.28$, $p < .001$.

Significant covariates of physical activity at T4 included pre-diagnosis physical activity ($r = .37$, $p < .001$), baseline mental HRQOL ($r = .19$, $p = .019$), income ($r = .16$, $p = .039$), race (Black: M = 682.27, SD = 625.16; White: M = 1013.74, SD = 911.72; $t(158) = 2.74$, $p = .007$), medical literacy (<HS: M = 648.66, SD = 653.50; HS: M = 953.18, SD = 856.61; $t(159) = 2.10$, $p = .038$) and employment status (not employed: M = 1041.44, SD = 950.14; employed full- or part-time: M = 741.44, SD = 672.14; $t(121) = 2.25$, $p = .026$). Graphs and leverage scores revealed 1 multivariate outlier, leaving N=160 in tests of the final model of Hypothesis 3 predicting physical activity at T4.

According to G*Power, in a regression model with 9 predictors (6 covariates, a predictor, moderator and interaction term), *N*=166 provides 95% power to detect a medium effect in the omnibus test of the regression model, while *N*=791 would provide 80% power to detect a small effect. To detect effects related to the change in R^2, *N*=89 would provide 95% power to detect a medium effect, while *N*=528 would provide 80% power to detect a small effect. Tests of Hypothesis 3 modeling T4 physical activity as the outcome variable therefore had excellent power to detect medium or large effects sizes, but lacked power to detect small effects.

The full multivariate model was significant, $F(9, 150) = 4.78$, $p < .001$, and explained 22% of the variance in T4 physical activity. As shown in Table 8, baseline mental HRQOL, race, medical literacy and income did not retain their significance in tests the full model. Only employment status and pre-diagnosis levels of physical activity significantly predicted that at T4. Controlling for covariates in the model, men who were employed full- or part-time at baseline obtained approximately 325 MET minutes/week more at T4 than men who were not employed. For every additional MET minute of weekly physical activity prior to diagnosis, men participated in .29 MET minutes at T4. Cancer worry, PTG and the interaction term were non-significant, and the latter did not contribute to the variance in the outcome (change in $R^2 = .002$, $p = .50$). This portion of Hypothesis 3 therefore was not supported.

Fruit and Vegetable Consumption

Prior to diagnosis, 70% of participants ate at least 1 fruit or vegetable daily, compared to 43% at T4. Accordingly, much of the sample reported a decline in fruit (46%) and vegetable (59%) consumption from pre-diagnosis to 5-year follow-up. For

vegetable consumption, 21% remained the same, while 20% increased. For fruits, 35% remained the same, and 20% increased.

In bivariate analyses, fruit/vegetable consumption at T4 was significantly related to several sociodemographic variables. Income (expressed in thousands of dollars) was higher among men who ate at least one fruit or vegetable each day (M = 31.44, SD = 14.92) compared to those who did not (M = 26.34, SD = 16.70), $t(166) = 2.06$, p =.041. Eating at least one fruit or vegetable per day at T4 also was less likely among men with lower education, $X^2(1, n=168) = 11.16$, p = .001, lower medical literacy, $X^2(1, n=168) = 6.35$, p = .012, Black (vs. White) men, $X^2(1, n=168) = 4.10$, p = .007, and men who ate at least one fruit or vegetable per day prior to prostate cancer diagnosis, $X^2(1, n=168) = 7.63$, p = .007. Baseline mental HRQOL also tended to be higher among men who ate more fruit/vegetables prior to diagnosis (M = 54.97, SD = 9.42) compared to those who did not (M = 50.62, SD = 10.52), $t(160) = 2.81$, p =.006.

Graphs and leverage scores revealed no multivariate outliers, leaving N=168 in tests of the final model of Hypothesis 3 predicting fruit/vegetable consumption at T4. According to G*Power, in a regression model with 9 predictors (6 covariates, a predictor, moderator and interaction term), N=166 provides 95% power to detect a medium effect in the omnibus test of the regression model, while N=791 would provide 80% power to detect a small effect. To detect effects related to the change in R^2, N=89 would provide 95% power to detect a medium effect, while N=528 would provide 80% power to detect a small effect. Tests of Hypothesis 3 modeling fruit/vegetable consumption as the outcome variable therefore had excellent power to detect medium or large effects sizes, but lacked power to detect small effects.

Using the Cox and Snell pseudo-R^2 statistic as a conservative estimate, the multivariate logistic regression model explained 15% of the variance in the dichotomous outcome representing T4 fruit/vegetable consumption and was statistically significant, $X^2(8) = 27.61$, $p = .001$. As shown in Table 9, only the initial measure of fruit and vegetable consumption significantly predicted T4 consumption in the full model; controlling for all other variables in the logistic regression model, eating at least 1 fruit or vegetable per day in the year prior to prostate cancer diagnosis significantly increased the likelihood of doing the same at T4 (OR = 2.40). However, this portion of hypothesis 3 was not supported, as cancer worry, PTG and the interaction term were non-significant.

Alcohol Use

Alcohol use varied widely across participants, with a range of 0 to 84 drinks per week ($M = 8.17$, $SD = 15.21$; median = .69) at baseline and 0 to 24 ($M = 2.98$, $SD = 4.95$; median = .50) at T4. At baseline, 57% of the sample averaged 2 or fewer alcoholic drinks per day, compared to 64% of the samples at T4. Nearly half of the sample (43%) reported decreased weekly alcohol use over the five years post-diagnosis. Because alcohol consumption at T4 was significantly positively skewed (skew = 2.20), log-based transformations were performed, resulting in a more normal distribution (skew = .84). The log-transformed variable therefore was retained for use in multivariate analyses. In addition, alcohol consumption at T1 and T4 were compared using non-parametric testing (i.e., Wilcoxon matched pairs test, rather than a paired samples *t*-test), revealing that alcohol consumption was significantly lower at T4 than in the year pre-diagnosis, $Z = -5.13$, $p < .001$.

Bivariate analyses revealed the following covariates of T4 alcohol use: pre-diagnosis alcohol use (r = .53, p < .001), baseline physical HRQOL (r = .16, p = .04), income (r = .26, p = .001), and race (Black: M = 1.71, SD = 3.56; White: M = 4.21, SD = 6.06; $t(156) = 3.45$, p = .001). According to G*Power, in a regression model with 7 predictors (4 covariates, a predictor, moderator and interaction term), N=153 provides 95% power to detect a medium effect in the omnibus test of the regression model, while N=725 would provide 80% power to detect a small effect. To detect effects related to the change in R^2, N=89 would provide 95% power to detect a medium effect, while N=395 would provide 80% power to detect a small effect. Tests of Hypothesis 3 modeling alcohol use as the outcome variable therefore lacked power to detect small effects but had excellent power to detect medium or large effects sizes.

The full multivariate model was significant, $F(7, 149) = 12.91$, p < .001, and explained 38% of the variance in T4 alcohol use. As shown in Table 10, baseline physical HRQOL, race, and income did not retain their significance in tests the full model. Only pre-diagnosis levels of alcohol use significantly, positively predicted that at T4; controlling for covariates in the model, for every one-unit increase in number of alcoholic drinks consumed per week in the year prior to prostate cancer diagnosis, alcohol consumption at five years post-diagnosis increased by 2%. Cancer worry, PTG and the interaction term were non-significant, and the latter did not contribute to the variance in the outcome (change in R^2 = .003, p = .41). This portion of Hypothesis 3 therefore was supported.

Sleep

Among five-year survivors of prostate cancer, 61% obtained 7-8 hours of sleep per night at T4. Covariates in preliminary analyses were race, comorbidity, baseline mental HRQOL and sleep at T2. Obtaining 7-8 hours of sleep per night was more common among White than Black men, $X^2(1, n=168) = 10.15$, $p = .002$, men with lower comorbidity levels, $X^2(1, n=168) = 8.75$, $p = .005$, and men who also slept 7-8 hours/night at T2, $X^2(1, n=168) = 35.84$, $p < .001$. Baseline levels of mental HRQOL in men who obtained 7-8 daily hours of sleep ($M = 54.70$, $SD = 8.78$) were higher than in men who slept <7 or ≥9 hours per night ($M = 49.03$, $SD = 11.47$), $t(165) = 3.60$, $p < .001$, whereas baseline levels of cancer worry were lower among men who obtained 7-8 daily hours of sleep ($M = 1.90$, $SD = .84$) compared to those who slept <7 or ≥9 hours per night ($M = 2.24$, $SD = 1.16$), $t(166) = 2.24$, $p = .027$.

Graphs and leverage scores revealed 3 multivariate outliers, leaving $N=165$ in tests of the final model of Hypothesis 3 predicting sleep at T4. According to G*Power, in a regression model with 7 predictors (4 covariates, a predictor, moderator and interaction term), $N=153$ provides 95% power to detect a medium effect in the omnibus test of the regression model, while $N=725$ would provide 80% power to detect a small effect. To detect effects related to the change in R^2, $N=89$ would provide 95% power to detect a medium effect, while $N=395$ would provide 80% power to detect a small effect. Tests of Hypothesis 3 modeling sleep as the outcome variable therefore had excellent power to detect medium or large effects sizes, but lacked power to detect small effects.

Using the Cox and Snell pseudo-R^2 statistic as a conservative estimate, the multivariate logistic regression model explained 26% of the variance in the dichotomous

outcome representing T4 sleep and was statistically significant, $X^2(7) = 49.86$, $p < .001$. As shown in Table 11, only the initial measure of sleep significantly predicted T4 sleep in the full model; controlling for all other variables in the logistic regression model, obtaining 7-8 hours of sleep per night at T2 significantly increased the likelihood of continuing to do so at T4 by 7.22 times. As cancer worry, PTG and the interaction term were non-significant in the full model, this portion of Hypothesis 3 was supported.

Hypothesis 4

Hypothesis 4 predicted that PTG would attenuate the negative relationship between comorbidity and perceived health. Because perceived health was relatively normally distributed, analysis proceeded using parametric tests without transforming the outcome variable. Perceived health at T1, just after prostate cancer diagnosis ($M = 3.70$, $SD = 1.01$), was modestly but significantly higher than perceived health at T4, approximately 5 years post-diagnosis ($M = 3.36$, $SD = .93$), $t(167) = 4.88$, $p < .001$. Most participants reported a decline (1-point decrease: $n = 58$, 34.5%; 2 point decrease: $n = 15$, 8.9%) or unchanged health over time ($n = 67$, 39.9%), while the remainder reported an improvement in perceived health (1-point increase: $n = 25$, 14.9%; 2 point increase: $n = 3$, 1.8%). No participants reported a change in perceived health of more than 2 points on this 5-point scale.

Although perceived health at both time points were significantly correlated ($r = .57$, $p < .001$), PTG significantly correlated with perceived health only at T1 ($r = -.15$, $p = .05$) but not at T4 ($r = .07$, $p = .38$). Perceived health at T4 differed significantly by comorbidity, $t(166) = 4.17$, $p < .001$; men with Charlson comorbidity index of 0 (i.e.,

lower risk of dying) at baseline had better T4 perceived health (M = 3.58, SD = .88) than men with Charlson comorbidity index of 1 or greater (M = 2.98, SD = .90).

In bivariate analyses to determine additional covariates of the outcome variable for Hypothesis 4, perceived health at T4, only income (r = .22, p = .005) and education, $t(166) = -2.43$, p = .02, were significant, such that men with more income and higher levels of education ($\leq$HS: M = 3.12, SD = .88; >HS: M = 3.48, SD = .94) had better health at T4. The remaining sociodemographic and medical variables were unrelated to T4 perceived health.

Upon examining graphs and leverage scores, three cases were identified as multivariate outliers and temporarily omitted, leaving N=165 in tests of the final model for hypothesis 4. According to G*Power, in a regression model with 6 predictors (3 covariates, predictor, moderator and interaction term), N=146 is required for 95% power to detect a medium effect in the omnibus test of this multiple regression, while N=688 is required for 80% power to detect a small effect. Regarding the power for detecting effects related to the change in R^2, N=89 is required for 95% power to detect a medium effect, while N=395 is required for 80% power to detect a small effect. This analysis was therefore well-powered to detect medium or large effects sizes, but under-powered for detecting small effects.

In multivariate analyses, the full model was significant, $F(6, 161) = 17.35$, $p <$ .001, and explained 40% of the variance in T4 perceived health. However, as shown in Table 12, contrary to Hypothesis 4, the interaction term was not significant and did not significantly contribute to the variance in T4 perceived health (change in R^2 = .003, p = .37). In addition, income and education did not remain significant predictors of T4

perceived health in the multivariate regression. Only T1 perceived health, comorbidity and PTG significantly predicted T4 perceived health. Not surprisingly, men who were in poorer health at baseline (as indicated by lower T1 perceived health and higher Charlson comorbidity index scores) also had poorer health at T4. In addition, controlling for socioeconomic covariates, prior health and comorbidity, men who reported more PTG resulting from their experience with prostate cancer also reported better T4 perceived health.

DISCUSSION

Survivors of prostate cancer and other challenging life experiences may not only report difficulties such as psychological distress but also improvements known as posttraumatic growth – i.e., enhanced relationships, religion/spirituality, appreciation of life, personal strength and new possibilities (Sawyer et al., 2010; Tedeschi & Calhoun, 1996). Research has overwhelmingly focused on predictors of PTG (Algoe & Stanton, 2009; Stanton et al., 2006). This approach may be appropriate, considering that the research construct (though not the concept) is relatively new, but understanding how PTG influences other outcomes is an important next step for the field (Algoe & Stanton, 2009).

Hypothetically, PTG may buffer the psychophysiologic effects of stress and facilitate improved health behaviors, thereby enhancing mental and physical health outcomes (Algoe & Stanton, 2009; Aspinwall & Tedeschi, 2010b; Bower et al., 2008). Although tests of these processes are emerging, results remain inconclusive. Moreover, generalizability of findings has been constrained by limited variability in the samples of cancer and other survivors studied thus far, which tend to be relatively affluent White women. Interpretation of initial results has been complicated by use of varied measures of the posttraumatic growth construct. This study therefore aimed to examine PTG as a moderator of multiple indicators of mental and physical health in a relatively diverse sample of prostate cancer survivors.

The sample of prostate cancer survivors available for this study was moderately sized (N=168). The sociodemographic heterogeneity of this sample is particularly important in light of the predominance of White, relatively affluent samples used in prior research on PTG in men with prostate cancer (e.g., Wilson et al., 2014), despite well-

documented prostate cancer disparities in terms of race and SES (American Cancer Society, 2016). Conversely, medical variability of the sample was limited; most men who participated in the T4 interview had a low or moderate Gleason score and cancer stage, and only 12% were classified as having highly aggressive prostate cancer. This sample might nonetheless be representative of the population of five-year survivors of prostate cancer, as men with indolent or regionally confined prostate cancer are much more likely than those with widely metastatic disease to survive five years post-diagnosis (American Cancer Society, 2016). Consistent with these objective indicators of cancer threat, the mean level of cancer worry in this sample was relatively low. Nonetheless, this group of five-year survivors of prostate cancer experienced, on average, a moderate degree of posttraumatic growth, which tended to be higher among men with greater cancer worry.

Hypothesis 1

Hypothesis 1 predicted that PTG would buffer the negative effects of cancer worry on subjective well-being. Cancer worry was measured at baseline, and the outcome was modeled separately as happiness and life satisfaction, both measured at T4. Hypothesis 1 was partially supported. In the test of happiness as the outcome, prior indicators of subjective well-being (life satisfaction and happiness at T2) were significant, as was the interaction term, such that cancer worry had a conditional effect on happiness. Controlling for covariates, when PTG was lower, cancer worry around the time of diagnosis and treatment predicted less happiness at 5 years post-diagnosis; at mean or higher levels of PTG, cancer worry and later happiness were unrelated.

When modeling life satisfaction as the outcome variable, the interaction was non-significant. However, the main effect of PTG on life satisfaction was significant, as were

prior levels of subjective well-being (again, life satisfaction and happiness at T2). In other words, controlling for race, age and income, men with equivalent levels of initial well-being reported more life satisfaction 5 years post-diagnosis if they also reported greater levels of PTG in response to their prostate cancer. In both models, baseline mental HRQOL was significant only in bivariate analyses but lost its significance in the multivariate models.

Thus, PTG in prostate cancer survivors appears to favorably influence subjective well-being via a direct effect on life satisfaction and by serving as a buffer against the deleterious effects of cancer worry on happiness. The latter finding is similar to a recent study in which PTG moderated the harmful effects of posttraumatic stress on positive affect among digestive cancer survivors (Ben-Zur et al., 2014). Thus, growing evidence suggests that PTG may buffer against the potential for cancer-related distress to contribute to decreased happiness among survivors. Moreover, the interaction effect identified in the current study may explain null findings in previous research; studies that have tested only main effects without investigating conditional direct effects (e.g., Barrington & Shakespeare-Finch, 2013; Salsman et al., 2009) may mask the nature of the relationship between PTG and positive affect.

On the other hand, when considering life satisfaction as an outcome, PTG does appear to play a direct, positive role, as supported by the current study's findings, as well as several prior studies using a range of cancer (Mols et al., 2009; Seitz et al., 2011) and non-cancer (Cann, Calhoun, Tedeschi, Kilmer, et al., 2010; Triplett et al., 2012) samples. Many view life satisfaction as a cognitive component of subjective well-being, as opposed to happiness as an affective facet (Sirgy, 2012). The growing support for a direct

relationship between PTG and life satisfaction thus follows naturally from the theoretical model of PTG, which posits that PTG develops largely through cognitive processes (Calhoun et al., 2010; Cann, Calhoun, Tedeschi, Kilmer, et al., 2010).

Methodological issues, such as the lack of power to detect small effects, also may have contributed to the different findings for happiness and life satisfaction. Happiness was measured with a single item and had less variability than the five-item measure of life satisfaction. Thus, future studies that use more robust measures of happiness and enroll more participants than the current study may continue to elucidate the role of PTG in determining subjective well-being.

Hypothesis 2

Hypothesis 2 predicted that PTG would buffer the effects of cancer worry and cancer-specific symptoms on HRQOL and symptom-related bother. HRQOL is a broad construct comprised of factors (e.g., pain, mood, functional limitations) related to mental and physical health (Ware et al., 1995), whereas disease-specific measures provide a more sensitive assessment of how patients are affected by a particular illness and its treatment (McHorney, 1999). This study measured two key domains of HRQOL using the mental and physical summary scores of the SF-12, as well as urinary, bowel, sexual and hormonal effects of prostate cancer (cancer-specific symptoms), and the extent to which participants view those symptoms as problematic (symptom-related bother).

Consistent with prior research (Bellizzi et al., 2008; Buckley et al., 2012; Chhatre et al., 2011; Davis et al., 2014; Diefenbach et al., 2008; Watson et al., 2016), bivariate analyses revealed that men in this sample who had more cancer worry and cancer-related symptoms tended to have poorer mental and physical HRQOL. Previous studies have

examined group differences in and predictors of HRQOL (e.g., Song et al., 2014; Ussher et al., 2016), but they have not examined the relationship between mental and physical HRQOL of prostate cancer survivors. In this sample, the two HRQOL subscales were unrelated at T4; longitudinal analyses revealed a significant correlation between baseline mental HRQOL and later physical HRQOL, but the relationship was non-significant in multivariate analyses described below.

Mental HRQOL

In multivariate models, prior mental HRQOL and happiness positively predicted later mental HRQOL. Age, cancer-specific symptoms, and PTG did not have significant main effects on mental HRQOL, nor did cancer worry. The interaction between cancer worry and PTG was significant, indicating that cancer worry is significantly related to mental HRQOL only at some values of PTG; this portion of hypothesis 2a therefore was supported. However, the probe of the interaction (i.e., examining the conditional effect of cancer worry at values of PTG equal to the mean and +/- 1 standard deviation) did not reveal any significant conditional effects of cancer worry on HRQOL. The lack of power to detect small effects in the current sample may explain this finding, particularly considering the trend toward significance at low levels of PTG. Alternately, cancer worry at or around the time of diagnosis may negatively predict mental HRQOL at 5 years post-diagnosis only for men with extremely low levels of PTG, though probing the interaction at quintiles of PTG (results not shown) also failed to reveal any significant conditional effects.

Contrary to prior research that has tended to show better mental HRQOL among older cancer survivors with higher socioeconomic status (e.g., Halbert et al., 2010; Song

et al., 2011), the current study found better mental HRQOL among older prostate cancer survivors only in bivariate analyses. Medical factors and other sociodemographic variables were unrelated to mental HRQOL in this sample. Findings regarding the role of PTG as a buffer for mental HRQOL are consistent with prior studies of cardiovascular and breast cancer patients (Bluvstein et al., 2013; Morrill et al., 2008; S. M. Silva, Moreira, et al., 2012). Thus, earlier psychological well-being appears to be the best predictor of mental HRQOL in 5-year survivors of prostate cancer, while PTG may protect men from negative effects of cancer-related distress on mental HRQOL.

Physical HRQOL

Many of the sociodemographic and medical variables measured in this study were significantly related to prostate cancer survivors' physical HRQOL at 5 years post-diagnosis. Consistent with prior findings (e.g., Aarts et al., 2010; Halbert et al., 2010; Jayadevappa et al., 2009; Song et al., 2011), prostate cancer survivors in this study tended to have better physical HRQOL if they were younger and White; had higher SES, less aggressive cancer, and better baseline health, psychological well-being, and HRQOL. Among the sociodemographic predictors, only age and medical literacy remained significant, while race, education, employment status and income lost their significance in multivariate analyses. This study therefore adds more evidence that racial differences in prostate cancer survivors' HRQOL may be confounded with disparities in SES and medical indicators.

Unlike earlier studies in which medical covariates were significant only in bivariate analyses (Hu et al., 2004; Potosky et al., 2001), comorbidity, PSA and receipt of treatment other than prostatectomy, radiation or androgen deprivation therapy all

remained significant predictors of physical HRQOL in the full model. Of particular importance for prostate cancer survivors, given their high rates of long-term survival and the potential for troublesome cancer- and treatment-related symptoms (American Cancer Society, 2016; Baker et al., 2016), initial cancer-specific symptoms such as urinary or sexual dysfunction did not influence later physical HRQOL when controlling for other factors in the multivariate model. Although prior studies have found a negative relationship between these symptoms and HRQOL (Bellizzi et al., 2008; Buckley et al., 2012; Chhatre et al., 2011; Davis et al., 2014; Watson et al., 2016), the longitudinal approach in the current study improves upon the cross-sectional focus of the existing literature and suggests that prostate cancer-specific symptoms may not harm long-term HRQOL.

While a couple of exceptions have been published (Arpawong et al., 2013; Jansen et al., 2011), this study adds to a growing body of evidence suggesting that PTG may be unrelated to cancer survivors' physical HRQOL (Bellizzi et al., 2010; Carboon et al., 2005; Mols et al., 2009; Steel et al., 2008). As opposed to the benefits of PTG for mental HRQOL noted above, PTG does not appear to protect against physical health-related dysfunction in survivors of prostate or other cancers. This suggests that PTG is neither a panacea nor an indicator of an excessively rosy response style. People are able to recognize ongoing health-related challenges, regardless of psychosocial benefits that also may result from their experience with cancer.

Symptom-Related Bother

In bivariate analyses, men who were employed full- or part-time, with higher income and fewer comorbidities tended to have less cancer-related symptom bother at

five years post-diagnosis, but socioeconomic status and medical comorbidity were not related to symptom bother in multivariate analyses. Similarly, indicators of subjective well-being were significantly related to cancer-specific well-being only in bivariate analyses; men with less symptom-related bother tended to be happier and report more life satisfaction than men with greater symptom-related bother, but only when examining bivariate correlations. The only variables that maintained their significance in tests of the full model predicting symptom-related bother at T4 were baseline levels of symptom-related bother, frequency of cancer-specific symptoms at T4, and physical and mental HRQOL at T4. This finding is consistent with several prior studies that have reported poorer HRQOL among prostate cancer survivors with more cancer-specific symptoms and symptom-related bother (Bellizzi et al., 2008; Buckley et al., 2012; Chhatre et al., 2011; Davis et al., 2014; Watson et al., 2016). Although not tested in the current study, prior research has shown that the association between cancer-specific symptoms and HRQOL can differ by symptom domain; in one study of prostate cancer survivors, bowel symptoms were the strongest predictor of mental and physical HRQOL (Davis et al., 2014). Cancer-specific symptoms and bother may be especially relevant to clinical care (Watson et al., 2016), while general HRQOL is an important measure of population-level health and well-being ("CDC - Concept - HRQOL," 2011). Thus, despite the significant overlap between HRQOL and cancer-specific symptoms/bother, the constructs are distinct and serve different purposes.

This is the first study to examine the relationship between PTG and prostate cancer-specific symptoms. In this sample, PTG was unrelated to cancer-specific symptom bother, and contrary to hypothesis 2, it failed to moderate the relationship between

symptom frequency and bother. These findings contrast those of the only other investigation of the association between PTG and cancer sequelae, in which breast cancer survivors who rated the effects of cancer as very troublesome also reported less PTG (Lelorain et al., 2010). However, the breast cancer study included more long-term survivors (women at 5 to 15 years post-diagnosis) and used a single categorical item, rather than a well-validated multi-item measure, to assess symptom-related bother. Moreover, prior research suggests that male and female cancer survivors may respond differently to cancer sequelae such as sexual dysfunction (Oudsten et al., 2012; Traa, Vries, Roukema, & Oudsten, 2012). In light of these differences, as well as the lack of power in the current study to detect small effects, researchers should continue to examine the relationship between PTG and cancer-related symptoms. For example, cancer survivors who experience positive changes such as greater appreciation of life have reported that they no longer "sweat the small stuff" (Addington et al., in preparation); future studies should therefore test whether survivors who report more PTG in this specific domain are less bothered by treatment sequelae.

Hypothesis 3

Using an approximation of the Health Beliefs Model, PTG was hypothesized to moderate the relationship between cancer worry and health behaviors that are closely related to cancer risk (i.e., smoking, physical activity, and diet) but not other health behaviors (i.e., alcohol use and sleep). Consistent with prior reports that prostate cancer survivors are less likely to smoke than adults without a history of cancer (LeMasters et al., 2014), a low proportion of participants in this study smoked post-diagnosis. Therefore, smoking was not examined further.

In multivariate analyses of the remaining health behavior outcomes, Hypothesis 3 was partially supported, in that PTG was not a significant moderator in tests predicting alcohol or sleep. However, contrary to Hypothesis 3, cancer worry, PTG and the interaction term also were non-significant in multivariate analyses predicting physical activity and diet. Because the current study lacked power to detect small effects, the potential remains for PTG to facilitate improved health behaviors among cancer survivors. Larger studies will need to examine this further and may benefit from including measures that are more specifically matched to theories of health behavior change. For example, the current study did not assess whether participants expect behaviors such as physical activity or fruit and vegetable consumption to decrease their risk of cancer recurrence, but such expectations are a key component of the Health Beliefs Model (Rosenstock et al., 1988).

For all of the health behavior outcomes examined in this study, prior behavior was the strongest, and often the only, predictor of health behaviors at five-year follow-up. For diet and sleep, these effects were particularly strong. Controlling for covariates, men who consumed at least 1 fruit or vegetable per day prior to diagnosis were more than twice as likely to continue to do so at 5 years post-diagnosis, and men who slept for 7-8 hours/night at T2 were more than 7 times as likely to also sleep 7-8 hours/night at T4. Effects were much smaller for physical activity and alcohol. Controlling for covariates, one MET minute/week pre-diagnosis predicted an increase of .29 MET minute/week at five years post-diagnosis, while an increase of one alcoholic drink per week at baseline predicted only a 2% increase in T4 alcohol consumption.

Although race, socioeconomic status, and baseline mental and/or physical HRQOL tended to predict health behaviors in bivariate analyses, these factors almost always became non-significant in multivariate tests of Hypothesis 3. The only exception was that, controlling for race, literacy, income and baseline levels of mental HRQOL and physical activity, employment remained significantly related to physical activity at T4, such that men who worked full- or part-time participated in over 300 more MET minutes of physical activity per week than men who were unemployed, retired or disabled. This finding is clinically significant, given that this quantity of physical activity is more than 60% of the minimum weekly amount (500 MET minutes – i.e., 150 minutes of moderate activity or 75 minutes of vigorous activity) recommended by both the US government and the American Cancer Society ("2008 Physical activity guidelines for Americans," 2008, "ACS guidelines for nutrition and physical activity," 2016). Additional research would be needed to fully elucidate the relationship between employment and physical activity, but it is possible that men who are employed are physically, financially and psychosocially more capable of engaging in regular exercise than men who are unemployed, retired or disabled.

Health behaviors ranged widely in this sample, but on average, participants' health behaviors tended to decline between the year prior to prostate cancer diagnosis and five-year follow-up. Fruit consumption decreased in 46% of men, vegetable consumption decreased in 59%, and physical activity decreased in 62%. In a relatively rare indicator of health improvement among this sample, 43% decreased their alcohol consumption from pre- to five years post-diagnosis. Given that pre-diagnosis amounts of sleep were not measured, a similar comparison cannot be made for this outcome.

The US government recommends that adult males eat 2000-2200 calories, including at least 2.5 cups of vegetables and 2 cups of fruit, each day ("A closer look inside healthy eating patterns - 2015-2020 dietary guidelines - health.gov," n.d.). Similarly, the American Cancer Society recommends that cancer survivors eat fruits and vegetables at every meal, totaling 2.5 cups of each per day ("ACS guidelines for nutrition and physical activity," 2016). The two groups also offer comparable recommendations for other health behaviors in adult males, including cancer survivors: 7-8 hours of sleep per night, a maximum of 2 alcoholic drinks per day, and as mentioned above, 500 or more MET minutes/week of physical activity ("2008 Physical activity guidelines for Americans," 2008, "A closer look inside healthy eating patterns - 2015-2020 dietary guidelines - health.gov," n.d., "ACS guidelines for nutrition and physical activity," 2016, "How Much Sleep Is Enough? - NHLBI, NIH," 2012).

In the year prior to prostate cancer diagnosis, 73% of the current sample met the recommendations for physical activity, and 57% met alcohol guidelines; at five years post-diagnosis, this fell to 55% for physical activity but increased to 64% for alcohol consumption. Similarly, 61% obtained the recommended 7-8 hours of sleep/night at five-year follow-up; pre-diagnosis measures of sleep were not obtained. An exact comparison of actual vs. recommended fruit and vegetable consumption is precluded by the format of the relevant item response options; however, T4 data indicates that most of the sample failed to meet dietary guidelines at five-year follow-up, given that only 43% ate at least one fruit or vegetable per day at that time. Tendency to meet dietary recommendations may have been higher pre-diagnosis, when 70% reportedly ate at least one fruit or vegetable per day.

Thus, although few prostate cancer survivors in this study reported smoking cigarettes post-diagnosis, health behaviors such as diet and exercise often worsened post-diagnosis. Instead of perceiving their diagnosis as a "wake-up call," many prostate cancer survivors ate fewer fruits and vegetables, exercised less, and sustained or increased their alcohol intake. This is consistent with prior research indicating that cancer often is not the "teachable moment" that many would assume it to be, particularly for male cancer survivors (Demark-Wahnefried et al., 2005, p. 5827; LeMasters et al., 2014; Mowls et al., 2016). Based on recent reports of negative associations between time since diagnosis and health behaviors in prostate, breast, and colorectal cancer survivors (Bluethmann et al., 2015), it is possible that people initiate health behavior changes in response to diagnosis, but fail to sustain them as cancer becomes less salient in long-term survivorship. Additionally, some cancer survivors might improve their behaviors, but not to the extent recommended by health organizations such as the American Cancer Society. This could explain why the current findings appear to contradict previous reports of an association between illness-related PTG and health behavior changes from studies using less rigorous measures (qualitative: Hefferon, Grealy, & Mutrie, 2009; single item: Low et al., 2014). Some cancer survivors, such as older African Americans, might need more education about specific changes that are likely to reduce their risk of negative cancer-related outcomes (Demark-Wahnefried et al., 2015; Harper et al., 2013). Even if cancer heightens their awareness of the importance of health behaviors and PTG inspires and empowers them, generally, to make the most of their lives, some survivors might need more detailed and culturally-tailored information in order to be able to translate general suggestions (e.g., "eat better") into actual behavior change, particularly when the benefits

of these changes are not always immediately perceptible (Demark-Wahnefried et al., 2015; Harper et al., 2013).

Health behavior interventions therefore remain a critical area for continued study. Interventions to facilitate improvements in multiple health behaviors at once (e.g., diet *and* exercise) are an emerging approach referred to as multiple health behavior change (MHBC). Initial evidence supports MHBC in people with or at risk of cancer, including prostate cancer survivors (Green, Hayman, & Cooley, 2015). Future research should continue to explore whether PTG influences health behaviors and perhaps moderates outcomes of MHBC interventions.

Hypothesis 4

Hypothesis 4 examined predictors of perceived health at approximately 5 years post-diagnosis (T4). In bivariate analyses, prior health (perceived health at T1 and Charlson comorbidity index, representing relative risk of dying within 1 year) and two indicators of socioeconomic status, income and education, were significantly related to T4 perceived health, such that men with poorer baseline health, less income and lower education also tended to report poorer health at T4. While this is consistent with well-documented health disparities among lower SES populations (Braveman, Cubbin, Egerter, Williams, & Pamuk, 2010), the lack of a significant relationship between T4 perceived health and other sociodemographic or medical covariates is surprising. Previous research with prostate cancer survivors found better perceived health among younger, White men with more education, fewer comorbidities and less aggressive cancer (Hoffman et al., 2015). Timing may explain these disparate findings, as Hoffman and colleagues assessed prostate cancer survivors' perceived health approximately 6 months

post-diagnosis, as opposed to 5 years post-diagnosis in the current sample. If replicated in other samples, the lack of a relationship between prostate cancer aggressiveness or treatment and perceived health at 5-year survival is an encouraging finding for the thousands of men who are expected to live for many years beyond a prostate cancer diagnosis.

In multivariate analyses, prior health remained the strongest predictor of later health, while socioeconomic variables were no longer significant. Hypothesis 4 was not supported, as PTG did not significantly moderate the relationship between comorbidity and perceived health. Nonetheless, PTG did have a significant direct effect on perceived health; controlling for prior health and socioeconomic status, men who reported more PTG stemming from prostate cancer also reported better health approximately 5 years post-diagnosis. Although this relationship was relatively small, with a one-point increase in PTG predicting only a tenth of a point improvement in health, it suggests that men who perceive more positive psychological changes in response to prostate cancer also view themselves to have better overall health.

Considering the amount of unexplained variance in T4 perceived health, as well as the exclusive use of self-report measures, other possible explanations for the relationship between PTG and perceived health in this sample should be examined in future research. For example, prior reviews have identified optimism as a predictor of both physical health and posttraumatic growth (Carver & Scheier, 2014; Kolokotroni et al., 2014). However, given that perceived health significantly predicts mortality in a wide array of samples (DeSalvo, Bloser, Reynolds, He, & Muntner, 2006), including prostate

cancer survivors (Hoffman et al., 2015) , the current findings should not be dismissed as mere Pollyannaism.

Strengths of the Current Study

In contrast to previous studies that have focused overwhelmingly on predictors of PTG (Algoe & Stanton, 2009), this study investigated mental and physical health outcomes related to PTG in a socioeconomically diverse sample of Black and White prostate cancer survivors from North Carolina. Considering the prevalence of prostate cancer, its high survival rates, and racial disparities (American Cancer Society, 2016), the current sample begins to fill an important gap in PTG research in oncology, which predominantly has enrolled relatively affluent White women with breast cancer. Further, most measures were administered near the time of diagnosis and initial treatment, and approximately five years post-diagnosis, thereby capturing two important time points in the continuum of cancer survivorship and allowing for longitudinal analyses, which are needed to clarify relationships between PTG and other outcomes. Use of long-term survivorship data also allows more complete development and resolution of the psychological and physiological stress-response processes (Algoe & Stanton, 2009). This study therefore is a notable step towards increasing our understanding of PTG among cancer survivors.

Limitations and Future Directions

Sample

As with any research, this project is not without its limitations. Despite having good to excellent power to detect medium and large effects in omnibus tests of the regression models and in tests of the change in R^2, several hundred additional participants

would be required to detect small effects. Research with larger samples therefore may uncover additional effects of PTG that were not statistically significant in the current study. Although the characteristics of this sample provide a needed contrast to prior studies, the sample is not representative of all cancer survivors, and results are interpreted in terms of the sample parameters (i.e., sample mean and standard deviation). For some variables – most notably, cancer worry – the restricted range of the current sample limits the percentage of the outcome variance that can be explained and could exaggerate the significance of other predictor variables; on the other hand, the range of cancer worry in this sample, which included almost no cases of severely aggressive prostate cancer, may reflect the population range of worry among men who have extremely high odds of surviving their prostate cancer. Regardless, findings from this study cannot be generalized to other samples or populations, such as men from other states or regions, different races/ethnicities, or survivors of other types or stages of cancer.

Prior studies of health behaviors illustrate the importance of continuing to sample from the diverse population of cancer survivors. For example, survivors of prostate cancer, compared to survivors of other non-breast cancers, are especially likely to improve their diet (Ollberding et al., 2011), yet consistent with the tendency for health behaviors to be poorest among cancer survivors living in the South compared to other US regions (Underwood et al., 2012), fruit and vegetable consumption was low among the current sample of men in North Carolina. Thus, future studies should examine group differences (e.g., gender, race/ethnicity, state/region, cancer type) in the relationship between PTG and health behaviors.

As noted above, most men in this study were diagnosed with low to moderately aggressive prostate cancer. Because they have remarkably higher five-year survival rates than men with more aggressive prostate cancer (American Cancer Society, 2016), they represent an important group. Nonetheless, exploring PTG and related outcomes in people with metastatic disease may be a fruitful target for future research. Initial findings suggest that PTG could preserve quality of life in patients with terminal cancer (Tang et al., 2014).

Research Design

In an attempt to enroll participants as soon after prostate cancer diagnosis as possible, PCaP used a service of the North Carolina Cancer Registry referred to as Rapid Case Ascertainment (Schroeder et al., 2006), yet most participants had already undergone prostate cancer treatment prior to completing the baseline interview. In addition, follow-up interviews were funded by a separate mechanism (the HCaP-NC study), leading to some inconsistencies and limitations of the survey design. For example, happiness, life satisfaction, and cancer-specific symptoms were not measured during the initial interview, and PTG was measured only at the final follow-up interview. This study therefore may not have captured participants' initial response to diagnosis (e.g., heightened cancer worry prior to choosing and receiving treatment) and cannot completely account for changes in PTG or other measures of participants' adjustment to prostate cancer over time.

Participants in this study completed the short form of the PTGI, which is relatively rare compared to the full 21-item version. Within the oncology literature, one study of young adult cancer survivors is a notable exception (Salsman et al., 2014). As

use of the PTGI-SF increases, meta-analyses can assess whether findings differ between studies using it in place of the original, longer version. Moreover, although the PTGI-SF demonstrated appropriate psychometric properties in this sample and in the original validation study, it is only appropriate for testing PTG overall, rather than separately testing the five PTG domains (Cann, Calhoun, Tedeschi, Taku, et al., 2010). Researchers will need to continue using the full-length PTGI if they aim to test, for example, whether specific domains such as appreciation of life differentially predict outcomes such as health behaviors.

In addition to PTG as the moderator, all of the primary predictor and outcome variables were measured with self-report surveys; most covariates, with the exception of some medical variables (e.g., PSA, cancer stage and grade, treatment type), also were self-reported. These variables remain important and often are associated with objective indicators, such as the significant negative relationship between perceived health and mortality in men with prostate cancer (Hoffman et al., 2015). However, self-reported measures can be flawed, biased, or otherwise inconsistently related to objective measures (Dunning, Heath, & Suls, 2004; Smith, 2007). For example, cancer survivors may over-report tobacco abstinence; nearly half of the cancer survivors in one study failed biochemical verification of their self-reported non-smoking status (Klesges et al., 2015). Moreover, individual characteristics such as obesity can influence the relationship between self-reported psychological status such as distress and the underlying physiologic processes (Benson et al., 2009).

Future research examining the relationship between PTG and mental and physical health outcomes therefore should incorporate additional measures, using objective

indicators when possible. The advent of wearable technology has facilitated the collection of more objective data for research, clinical and personal use (Schulmeister, 2016); for instance, devices for measuring physical activity have proliferated over the last decade (Sanders et al., 2016). Researchers also will need to continue using laboratory measures, such as biomarkers of stress and immunity. If PTG is shown to influence these outcomes, then PTG in cancer survivors may counteract the reduced immune function that typically results from radiation and chemotherapy (Antoni & Lutgendorf, 2007). Similarly, a prior study reported that higher levels of positive affect predicted a healthier inflammatory response to radiation therapy for breast or prostate cancer (Sepah & Bower, 2009). The results of the current study therefore suggest that PTG may protect the physical health of cancer survivors, at least in part, through its role as a buffer for the negative relationship between cancer worry and happiness (hypothesis 1), but future studies will need to test this hypothesis using biomarkers such as proinflammatory cytokines.

This study did not examine all possible models of the relationship between PTG and mental and physical health outcomes among prostate cancer survivors. Analysis of curvilinear models may be warranted, based on prior oncology studies that reported quadratic relationships between PTG or benefit-finding and HRQOL, affect, and depressive symptoms (Lechner, Carver, Antoni, Weaver, & Phillips, 2006; Tomich & Helgeson, 2012). In addition, relationships between some of the variables tested in this study may be bidirectional. Physical activity, for instance, can build positive emotions and psychosocial resources (Hogan, Catalino, Mata, & Fredrickson, 2015), and some have suggested that it may contribute to the development of PTG among cancer survivors (Crawford et al., 2014). However, longitudinal tests of this effect and randomized

controlled trials of physical activity interventions to develop PTG have not yet been conducted.

Conclusions

This study investigated whether PTG serves a protective role in the mental and physical health of five-year survivors of prostate cancer. In multivariate analyses predicting subjective well-being, HRQOL, cancer-specific symptoms, health behaviors and perceived health, baseline levels of each outcome typically remained the strongest predictor of later outcomes. Nonetheless, controlling for these and other covariates, PTG buffered the negative effects of cancer worry on happiness and mental HRQOL, and it directly predicted greater life satisfaction and better perceived health. Although PTG was not related to physical HRQOL, cancer-related symptoms, or health behaviors in this sample, this study was not powered to detect small effects; thus, larger samples may reveal additional effects of PTG. Future studies therefore should continue to examine outcomes related to PTG in diverse samples of cancer survivors, expanding into other types of cancers diagnosed in both men and women at varying cancer stages or grades. In addition, interventions are needed to improve and sustain health behaviors among prostate cancer survivors, many of whom fail to meet recommended levels of physical activity and fruit and vegetable consumption regardless of their levels of PTG.

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APPENDIX A: TABLES

TABLE 1: Participant characteristics

Sociodemographic variables	*M* (*SD*)	*n* (%)
Race: Black		70 (41.7)
White		98 (58.3)
Married or living as married		131 (78.0)
Education: ≤HS		58 (34.5)
>HS		110 (65.5)
Literacy: <HS		44 (26.2)
≥HS		124 (73.8)
Employed (full- or part-time)		94 (56.0)
Income/person[a]	28,835 (16,222)	
Medical variables	***M* (*SD*)**	***n* (%)**
Age at diagnosis	61.34 (7.97)	
Time since diagnosis		
T1 (days)	166.73 (107.12)	
T4 (years)	5.19 (.81)	
CCI: 0		106 (63.1)
1+		62 (36.9)
Personal history of any cancer: yes		21 (12.5)
Family history of CaP: yes[a]		65 (38.7)
Gleason score: 4-5		10 (6.0)
6-7		144 (85.7)
8-10		14 (8.3)
Cancer stage: T1		115 (68.5)
T2		49 (29.2)
T3-4		2 (1.2)
PSA	7.23 (6.72)	
Aggressiveness: Low		94 (56.0)
Intermediate		54 (32.1)
High		20 (11.9)
Total number of CaP treatments[a]: 0		19 (11.3)
1		85 (50.6)
≥2		60 (35.7)
Prostatectomy[a]: yes		120 (71.4)
External beam radiation[a]: yes		51 (30.4)
Hormone therapy[a]: yes		32 (19.0)
Other treatment[a,b]: yes		24 (14.3)

Note. *N*=168. HS = high school, CaP = prostate cancer, CCI = Charlson comorbidity index, PSA = prostate-specific antigen, T1 = time 1, T4 = time 4.
[a]Variables with missing data are shown prior to hot deck imputation.
[b]Other treatment includes watchful waiting/active surveillance, brachytherapy, transurethral resection of the prostate (TURP), and clinical trials (e.g., high intensity focused ultrasound, HIFU).

TABLE 2: Descriptive statistics and correlations for variables of primary interest

Variable	*N*	*M* (*SD*)	1	2	3	4	5	6	7	8
1. Cancer Worry	168	2.03 (.99)								
2. PTG	168	2.75 (1.44)	.17*							
3. Happiness	166	7.83 (1.69)	-.13	.14						
4. Life Satisfaction	168	3.82 (.87)	-.11	.15*	.71***					
5. Mental HRQOL	165	51.81 (9.73)	-.16*	.04	.60***	.48***				
6. Physical HRQOL	165	46.35 (10.74)	-.21**	-.03	.16*	.19*	.05			
7. EPIC-Function	168	46.73 (21.86)	.10	.10	.19*	.23**	.21**	.21**		
8. EPIC-Bother	168	85.70 (13.67)	-.03	-.03	.29***	.48***	.48***	.40***	.40***	
9. EPIC-Total	168	73.91 (13.84)	.03	.03	.31***	.45***	.45***	.38***	.77***	.89***

Note. Cancer worry measured at Time 1; all other measures administered at Time 4. *N* shows number of participants with valid data for each variable. Correlations based on pair-wise deletion. * indicates $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$. PTG = posttraumatic growth, HRQOL = health-related quality of life, EPIC = Expanded Prostate Cancer Index Composite (measure of prostate cancer-specific symptoms).

TABLE 3: Test for the interactive effect between cancer worry and posttraumatic growth on happiness at T4 (Hypothesis 1)

	b	SE	*p*	95% CI
(Intercept)	7.77***	.11	<.001	7.56, 7.98
Mental HRQOL (T1)	.01	.01	.43	-.01, .04
Life satisfaction (T2)	.53***	.15	<.001	.23, .84
Happiness (T2)	.32***	.09	<.001	.14, .51
CW	-.12	.12	.34	-.36, .12
PTG	.15	.08	.06	-.004, .31
CWxPTG	.18*	.08	.03	.02, .35
Conditional effects of CW	$\Delta R^2 = .02$, $F(1, 155) = 5.05$, $p = .026$			
PTG	*b*	SE	*p*	95% CI
M-1*SD*	-.37*	.19	.048	-.74, -.004
M	-.11	.12	.36	-.35, .13
M+1*SD*	.15	.15	.30	-.14, .44

Note. $N = 162$. * indicates $p \leq .05$, *** $p \leq .001$. *b* = unstandardized beta weight, CI = confidence interval. T1 = Time 1, T2 = Time 2, T4 = Time 4. CW = cancer worry, HRQOL = health-related quality of life, PTG = posttraumatic growth, CWxPTG = interaction term. All covariates, CW and PTG were mean-centered prior to computing the interaction term.

TABLE 4: Test for the interactive effect between cancer worry and posttraumatic growth on life satisfaction at T4 (Hypothesis 1)

	b	SE	*p*	95% CI
(Intercept)	3.82***	.07	<.001	3.67, 3.96
Race (Black=0)	-.04	.12	.75	-.28, .20
Income	.01	.003	.09	-.001, .01
Age at diagnosis	.01	.01	.20	-.004, .02
Mental HRQOL (T1)	.01	.01	.15	-.003, .02
Life satisfaction (T2)	.39***	.07	<.001	.24, .53
Happiness (T2)	.09*	.05	.049	.001, .19
CW	-.01	.06	.82	-.13, .10
PTG	.09*	.04	.02	.01, .17
CWxPTG	.04	.04	.29	-.03, .11

Note. $N = 162$. * indicates $p \leq .05$, *** $p \leq .001$. *b* = unstandardized beta weight, T1 = Time 1, T2 = Time 2, T4 = Time 4. CW = cancer worry, HRQOL = health-related quality of life, PTG = posttraumatic growth, CWxPTG = interaction term. Income, age at diagnosis, mental HRQOL, life satisfaction at T2, happiness at T2, CW and PTG are centered at the mean.

TABLE 5: Test for the interactive effects of posttraumatic growth with cancer worry and cancer-specific symptoms on mental HRQOL at T4 (Hypothesis 2)

	b	SE	*p*	95% CI
(Intercept)	51.54***	.66	<.001	50.24, 52.84
Age at diagnosis	.09	.09	.30	-.09, .28
Mental HRQOL (T1)	.26***	.08	.001	.10, .42
Life satisfaction (T2)	.30	.98	.76	-1.64, 2.24
Happiness (T2)	1.87**	.59	.002	.70, 3.04
CW (T1)	-.59	.74	.42	-2.05, .86
EPIC (T2)	.04	.06	.45	-.07, .15
PTG (T4)	.29	.49	.56	-.67, 1.25
CWxPTG	1.10*	.51	.03	.09, 2.10
EPICxPTG	.01	.04	.86	-.07, .09
Conditional effects of CW	ΔR^2 = .02, $F(2, 148) = 4.63$, $p = .03$			
PTG	*b*	SE	*p*	95% CI
M-1*SD*	-2.07	1.14	.07	-4.33, .18
M	-.53	.73	.47	-1.97, .91
M+1*SD*	1.02	.89	.25	-.74, 2.78

Note. $N = 158$. * indicates $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$. *b* = unstandardized beta weight, CI = confidence interval. T1 = Time 1, T2 = Time 2, T4 = Time 4. HRQOL = health-related quality of life, CW = cancer worry, EPIC = cancer-related symptoms, PTG = posttraumatic growth. CWxPTG and EPICxPTG represent the interaction terms. All first-order terms were mean-centered.

TABLE 6: Test for the interactive effects of posttraumatic growth with cancer worry and cancer-specific symptoms on physical HRQOL at T4 (Hypothesis 2)

	b	SE	*p*	95% CI
(Intercept)	48.34***	2.52	<.001	43.36, 53.31
Race (Black=0)	.12	1.66	.94	-3.17, 3.40
Education (≤HS=0)	2.39	1.75	.18	-1.08, 5.85
Medical literacy (<HS=0)	-4.15*	1.89	.03	-7.87, -.43
Employment status (not employed=0)	-2.04	1.49	.17	-4.99, .91
Income	.03	.05	.57	-.07, .12
Age at diagnosis	-.30**	.11	.008	-.52, -.08
Comorbidity (CCI 0=0)	-4.67**	1.47	.002	-7.57, -1.77
PSA	-.23*	.11	.04	-.46, -.01
Cancer stage (T1=0)	-.38	1.42	.79	-3.18, 2.42
Other treatment (no=0)	4.74*	2.09	.025	.61, 8.87
Mental HRQOL (T1)	-.003	.08	.97	-.16, .15
Physical HRQOL (T1)	.30***	.07	<.001	.17, .43
Life satisfaction (T2)	.03	1.00	.98	-1.95, 2.00
Happiness (T2)	1.37*	.59	.022	.20, 2.54
CW	.15	.76	.84	-1.35, 1.65
EPIC	.06	.06	.32	-.05, .17
PTG	.55	.52	.30	-.49, 1.58
CWxPTG	-.23	.48	.63	-1.18, .71
EPICxPTG	-.02	.04	.58	-.10, .06

Note. $N = 160$. * indicates $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$. *b* = unstandardized beta weight, CI = confidence interval. T1 = Time 1, T2 = Time 2, T4 = Time 4. HS = high school, CCI = Charlson comorbidity index, PSA = prostate specific antigen, HRQOL = health-related quality of life, CW = cancer worry, EPIC = cancer-specific symptoms, PTG = posttraumatic growth. CWxPTG and EPICxPTG represent the interaction terms. All first-order terms were mean-centered.

TABLE 7: Test for the interactive effect between cancer-specific function and posttraumatic growth on symptom-related bother at T4 (Hypothesis 2)

	b	SE	*p*	95% CI
(Intercept)	85.18***	1.24	<.001	82.73, 87.62
Employment status (not employed=0)	.72	1.68	.67	-2.60, 4.04
Income	-.02	.05	.71	-.13, .09
Comorbidity (CCI 0=0)	.87	1.82	.63	-2.73, 4.47
Mental HRQOL (T4)	.58***	.11	<.001	.38, .79
Physical HRQOL (T4)	.31***	.09	<.001	.13, .49
Life satisfaction (T4)	-.43	1.41	.76	-3.21, 2.36
Happiness (T4)	-.85	.77	.27	-2.36, .67
EPIC-Bother (T2)	.36***	.07	<.001	.22, .49
EPIC-Function (T4)	.10*	.04	.01	.02, .18
PTG	-.23	.48	.63	-1.18, .71
EPIC-Function(T4)xPTG	.01	.02	.68	-.04, .06

Note. $N = 160$. * indicates $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$. *b* = unstandardized beta weight, T1 = Time 1, T2 = Time 2, T4 = Time 4. CCI = Charlson comorbidity index, EPIC-Function = frequency of prostate cancer-specific symptoms, EPIC-Bother = cancer-specific bother, HRQOL = health-related quality of life, PTG = posttraumatic growth. EPIC-Function(T4)xPTG = interaction term. All continuous first-order terms were centered at the mean.

TABLE 8: Test for the interactive effect of cancer worry and posttraumatic growth on physical activity at T4 (Hypothesis 3)

	b	SE	*p*	95% CI
(Intercept)	660.94***	170.31	<.001	324.42, 997.46
Race (Black=0)	-169.62	142.22	.23	-450.64, 111.40
Medical literacy (<HS=0)	181.97	157.92	.25	-130.05, 493.99
Employment (not employed=0)	325.91**	123.05	.009	82.77, 569.05
Income	3.87	4.29	.37	-4.60, 12.33
Mental HRQOL (T1)	6.83	6.40	.29	-5.81, 19.47
Physical activity (T1)	.29***	.07	<.001	.16, .42
CW (T1)	-26.78	67.02	.69	-159.21, 105.64
PTG	11.57	46.92	.81	-81.13, 104.28
CWxPTG	29.55	43.73	.50	-56.85, 115.95

Note. $N = 160$. ** indicates $p \leq .01$, *** $p \leq .001$. *b* = unstandardized beta weight, T1 = Time 1, T4 = Time 4. CW = cancer worry, HRQOL = health-related quality of life, HS = high school, PTG = posttraumatic growth. CWxPTG represents the interaction term. All continuous first-order terms were centered at the mean.

TABLE 9: Logistic regression model testing for the interactive effect between cancer worry and posttraumatic growth on fruit and vegetable consumption at T4 (Hypothesis 3)

	b	SE	*p*	OR
(Intercept)	-1.75**	.55	.002	.18
Race (Black=0)	-.22	.40	.57	.80
Education (≤HS=0)	.80	.46	.08	2.23
Medical literacy (<HS=0)	.51	.49	.30	1.67
Income	.01	.01	.47	1.01
Mental HRQOL (T1)	.04	.02	.053	1.04
Fruit/vegetable at T1 (<1/day=0)	.88*	.41	.03	2.40
CW (T1)	-.04	.20	.83	.96
PTG	.18	.14	.20	1.19
CWxPTG	-.12	.13	.37	.89

Note. $N = 168$. * indicates $p \leq .05$, ** $p \leq .01$. *b* = unstandardized beta weight, T1 = Time 1, T4 = Time 4. CW = cancer worry, HRQOL = health-related quality of life, HS = high school, PTG = posttraumatic growth. CWxPTG represents the interaction term. All continuous first-order terms were centered at the mean.

TABLE 10: Test for the interactive effect of cancer worry and posttraumatic growth on alcohol consumption at T4 (Hypothesis 3)

	b	SE	*p*	95% CI
(Intercept)	.43***	.04	<.001	.35, .50
Race (Black=0)	-.12	.06	.07	-.24, .01
Income	.003	.002	.06	-.0002, .008
Physical HRQOL (T1)	.004	.003	.09	-.001, .01
Alcohol (T1)	.02***	.002	<.001	.01, .02
CW (T1)	-.02	.03	.52	-.08, .04
PTG	-.01	.02	.73	-.05, .03
CWxPTG	.02	.02	.41	-.02, .06

Note. $N = 157$. *** indicates $p \leq .001$. *b* = unstandardized beta weight, T1 = Time 1, T4 = Time 4. CW = cancer worry, HRQOL = health-related quality of life, PTG = posttraumatic growth. CWxPTG represents the interaction term. All continuous first-order terms were centered at the mean. Outcome variable was log-transformed.

TABLE 11: Logistic regression model testing for the interactive effect between cancer worry and posttraumatic growth on sleep at T4 (Hypothesis 3)

	b	SE	*p*	OR
(Intercept)	-.30	.40	.45	.74
Race (Black=0)	-.16	.42	.70	.85
CCI (CCI 0=0)	-.63	.39	.11	.53
Mental HRQOL (T1)	.03	.02	.18	1.03
Sleep at T2 (7-8 hours=1)	1.98***	.40	<.001	7.22
CW (T1)	-.26	.22	.23	.77
PTG	-.11	.15	.46	.90
CWxPTG	-.01	.14	.94	.99

Note. $N = 168$. *** indicates $p \leq .001$. *b* = unstandardized beta weight, T1 = Time 1, T2 = Time 2, T4 = Time 4. CCI = Charlson comorbidity index, CW = cancer worry, HRQOL = health-related quality of life, PTG = posttraumatic growth. CWxPTG represents the interaction term. All continuous first-order terms were centered at the mean.

TABLE 12: Test for the interactive effect between comorbidity and posttraumatic growth on perceived health at T4 (Hypothesis 4)

	b	SE	*p*	95% CI
(Intercept)	3.38***	.11	<.001	3.16, 3.61
Income	.01	.004	.12	-.001, .01
Education	.14	.14	.31	-.13, .41
Perceived health (T1)	.46***	.06	<.001	.34, .59
CCI	-.33**	.13	.01	-.57, -.08
PTG	.10*	.05	.04	.003, .20
PTGxCCI	.08	.09	.37	-.09, .25

Note. $N = 166$. * indicates $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$. *b* = unstandardized beta weight; CI = confidence interval. CCI = Charlson comorbidity index; PTG = posttraumatic growth; PTGxCCI represents the interaction term. T1 = Time 1, T4 = Time 4. Income, perceived health at T1, and PTG are centered at the mean.

APPENDIX B: FIGURES

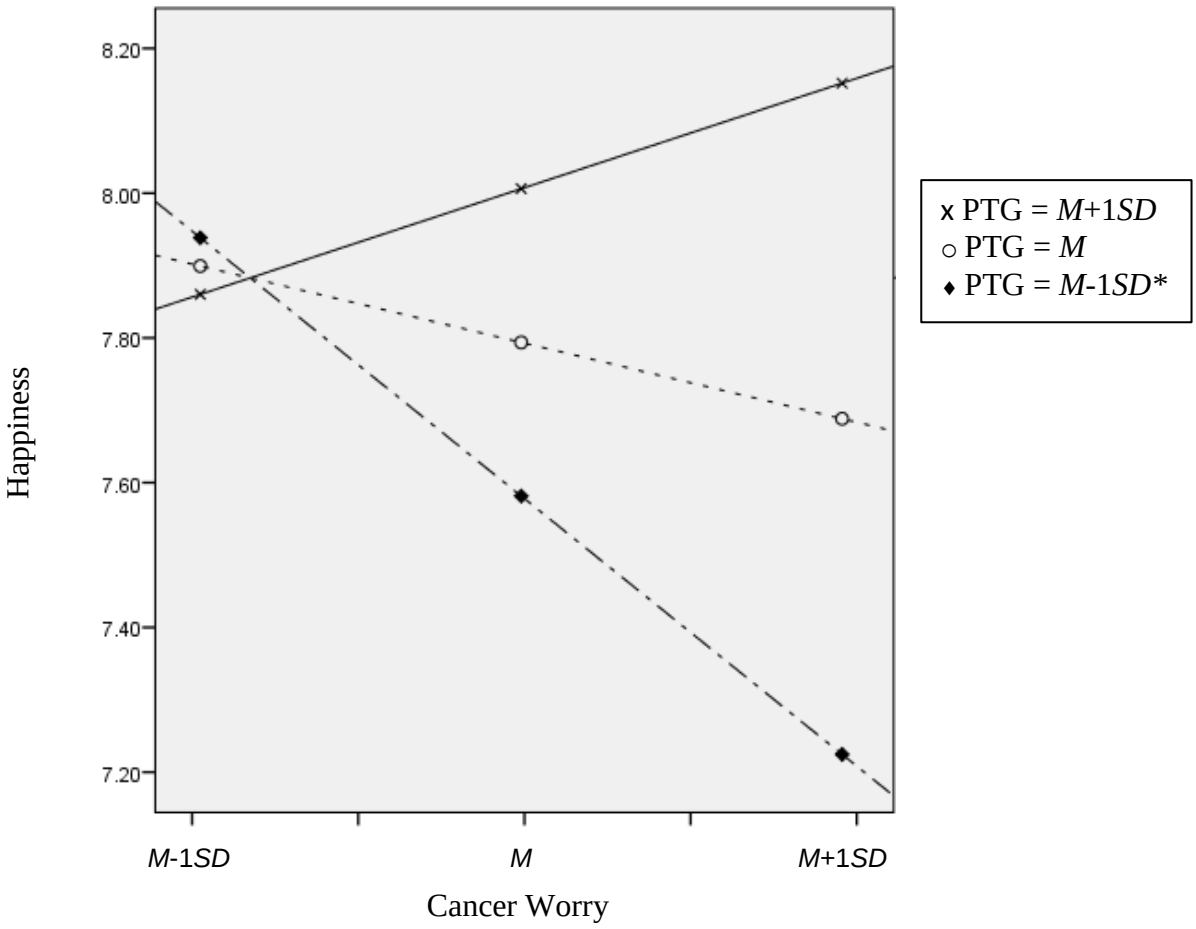

FIGURE 1: Interactive effect of cancer worry and posttraumatic growth on happiness at approximately five years post-diagnosis

Note. * indicates $p < .05$. PTG = posttraumatic growth. Cancer worry and PTG were mean-centered.

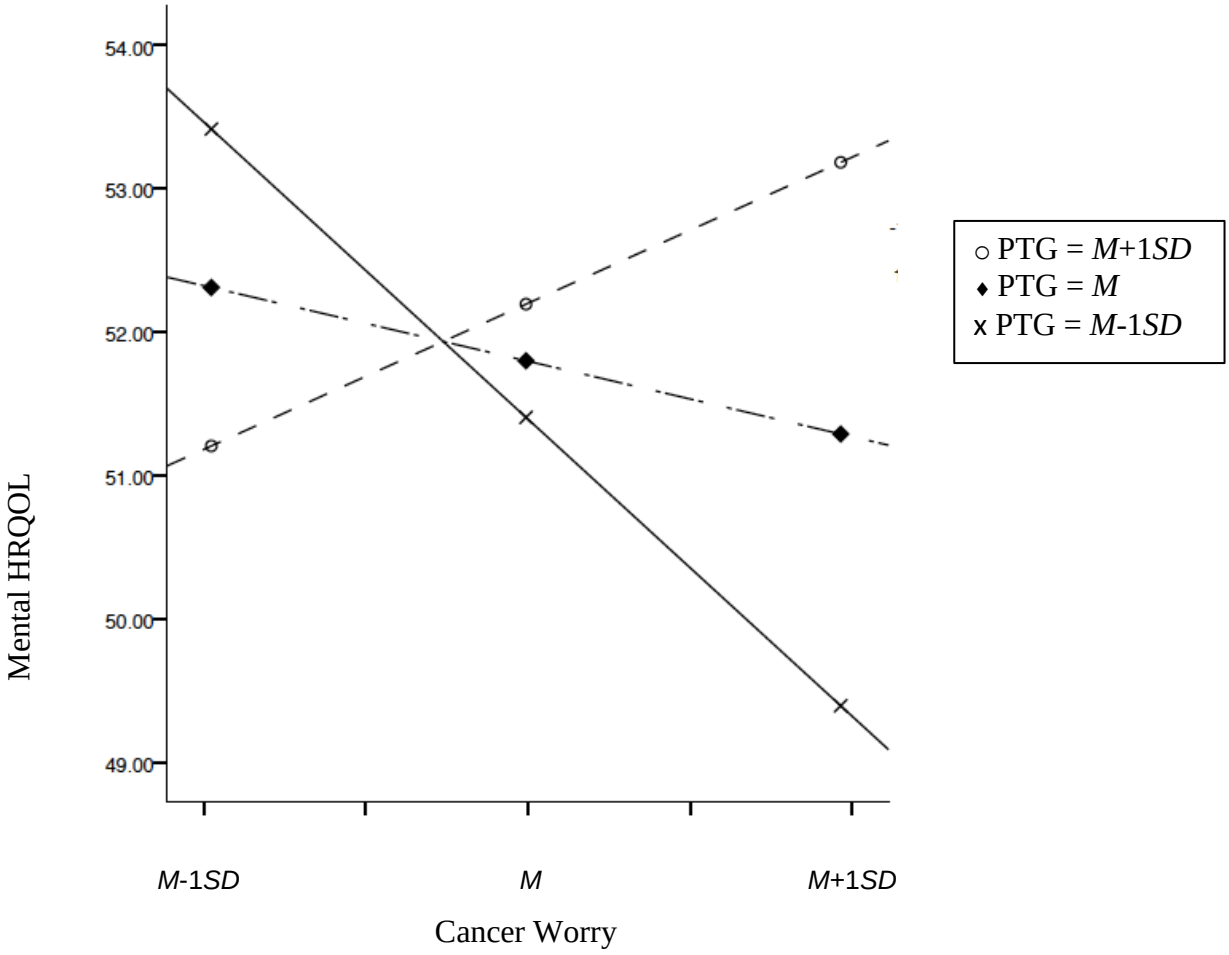

FIGURE 2: Interactive effect of cancer worry and posttraumatic growth on mental HRQOL at approximately five years post-diagnosis

Note. All slopes are statistically non-significant. HRQOL = health-related quality of life; PTG = posttraumatic growth. Cancer worry and PTG were mean-centered.