The Co-occurrence of Posttraumatic growth (PTG) and Posttraumatic stress disorder (PTSD) in
cancer survivors from a network perspective

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Abstract

A cancer diagnosis is a stressful life event that can lead to posttraumatic reactions. The two most common posttraumatic reactions in cancer survivors are posttraumatic stress disorder (PTSD) and posttraumatic growth (PTG). PTSD represents the negative changes and PTG the positive changes resulting from the process of adapting to cancer. The PTSD, PTG and combined PTSD-PTG network structure with bridge nodes were estimated in 696 adult cancer survivors. The most central indicators in the PTG network were *putting more effort into relationships, the ability to do better things with one's own life* and *a greater sense of closeness with others*. The most central symptoms in the PTSD network were *being jumpy or startled* and *cancer-related flashbacks*. *Hypervigilance* (PTSD symptom), *knowing better that one can handle difficulties* and *changing priorities about what is important in life* (PTG indicators) were identified as the nodes that link PTSD and PTG. In the cancer survivors with lower and higher levels of PTG, PTSD network structure, and the PTG strength of centrality indicators were different. In addition, PTSD and PTG were linked through different bridge nodes. This supports the hypothesis that PTSD and PTG are related differently in people with low and high PTG. The network approach can bring new insight into understanding the negative and positive posttraumatic reactions and their co-occurrence in cancer survivors.

Keywords: Cancer, Posttraumatic growth, Posttraumatic stress, Network analysis, Trauma

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The Co-occurrence of Posttraumatic growth (PTG) and Posttraumatic stress disorder (PTSD) in patients with cancer from a network perspective

A cancer diagnosis is a serious life event that leads to experiencing increased distress (Carlson et al., 2019; Kirk et al., 2021; Mehnert et al., 2018). In some patients, this initial distress may develop into more serious mental health issues. This may persist for a long time following the cancer diagnosis and even in cancer survivors in long-term remission (Brandenburg et al., 2019). In certain patients, cancer-related PTSD can develop (6.4% for current prevalence, and 12.6% for lifetime cancer-related PTSD (Abbey et al., 2015)). PTSD is a mental health issue accompanied by intrusive thoughts, flashbacks, sleep disturbances, avoidant behavior, negative emotions and cognition, physiological reactions and other changes in behavior.

On the other hand, surviving cancer can also lead to positive changes known as posttraumatic growth (Li et al., 2020). Posttraumatic growth (PTG) represents the positive psychological changes which result from the fight with a traumatic event. PTG is experienced as a consequence of coping with a traumatic event (Tedeschi et al., 2018). According to the PTG theory, the occurrence of PTG requires the experience of certain distress which acts as a trigger and enhancer of restructuring, e.g., of core beliefs (Tedeschi & Calhoun, 2004). This part of the PTG theory is also supported by research findings that have indicated the coexistence of PTSD and PTG (Cao et al., 2018). A predominantly weak to moderate positive relationship has been reported between PTSD and PTG in previous studies (Jin et al., 2014; Marziliano et al., 2020; Shand et al., 2015). However, this relationship appears to be curvilinear rather than linear (Shakespeare-Finch & Lurie-Beck, 2014). As there is considerable heterogeneity in the findings of studies which have examined the link between PTSD and PTG, the relationship between PTSD and PTG is still being examined (Peters et al., 2021).

The network approach brings new possibilities to the study of these posttraumatic phenomena and their interconnection (McNally, 2016; McNally et al., 2015; Robinaugh et al., 2020). Within this approach, the variable is not seen as a latent variable but rather as a network of symptoms (indicators) (Borsboom & Cramer, 2013). It is then possible to identify the importance of individual indicators (symptoms) within the network, which may be essential for its development, maintenance and extinction. In this analysis, it is possible to find which indicator (symptom) could represent a suitable target for intervention (Borsboom, 2017; Boschloo et al., 2015). At the same time, the network approach brings new possibilities for understanding the mutual occurrence and interconnection of various psychological phenomena (Cramer et al., 2010) through the identification of so-called bridge symptoms (Jones et al., 2021). This approach has also been useful in the study of comorbidity (Fried et al., 2017) between PTSD and other mental health issues such as depression, anxiety disorder and substance use disorder (Afzali, Sunderland, Batterham, et al., 2017; Afzali, Sunderland, Teesson, et al., 2017; Duek et al., 2021; Price et al., 2019). It has also been used in the study of various psychological phenomena, such as the occurrence of complicated grief and PTG (Bellet et al., 2018), or PTSD and PTG (Yuan et al., 2021). PTSD and PTG have been widely examined and well-documented phenomena in cancer patients (or cancer survivors) (Kou et al., 2021; Swartzman et al., 2017). However, it appears that cancer-related PTSD may be an underestimated and neglected issue in cancer patients (Caruso & Breitbart, 2020; Cordova et al., 2017; Leano et al., 2019). There is a considerable literature and research gap in addressing the network structure of PTSD, PTG as well as their co-occurrence in cancer survivors. The study of PTSD and PTG and their coexistence from the network perspective could thus shed new light on the understanding of these posttraumatic reactions in cancer patients.

This study aims to analyse three networks. The first network consists of the indicators of posttraumatic growth while the second looks at the network within PTSD symptoms. The third is a combined network of PTSD symptoms and PTG indicators, with bridge indicators (symptoms).

Methods

Sample and Procedures

The questionnaires were administered between July 2019 and July 2020 to cancer survivors in 4 hospitals and 5 different cancer support groups in different parts of Slovakia. This study is part of the project “Cognitive-existential profile and specifics of posttraumatic growth in cancer survivors” (osf.io/4maz9/). Ethical approval was granted in June 2018 by the Ethical Committee at Trnava University (resolution No. 1/2018), the National Cancer Institute and the hospital management. The research was carried out according to the Declaration of Helsinki. Participation in the study was voluntary and patients could leave the research at any stage without any consequences. Patients confirmed their participation in the study by providing informed consent. There were no questions in the questionnaire which were forced, and patients could leave a response blank in the case that they did not wish to answer. The questionnaires were administered individually or in groups. In most cases, the data collection was carried out in person while around 100 patients took part online. There were three different versions of the questionnaire with the three questionnaire parts (measures) in a different order. This aimed to reduce the bias which can occur due to the effect that order can have on participant responses (e.g., Chan (1991); Krosnick & Alwin (1987)). After completing the questionnaires, the participants were given a short debriefing. The inclusion criteria were being 18 or older, having been diagnosed with cancer, not having severe mental health or physical condition, and not being terminally ill – the data collection was not carried out in a palliative care unit.

Selection of Cancer Survivors

Marzorati et al. (2017) have defined cancer survivorship as a process that begins at the moment of diagnosis and continues throughout their life. There was no strict selection of cancer survivors based on the stage of cancer survivorship (Mullan, 1985) or by the specific type of diagnosis. Rather, our study aimed to catch the natural heterogeneity of cancer diagnosis in Slovakia as well as avoid selection bias (Pedhazur & Schmelkin, 1991).

Measures

The **Posttraumatic Growth Inventory** (PTGI; Tedeschi & Calhoun, 1996) consists of a 21 items which measures whether a traumatic event can also cause a positive change in the sense of positive growth. The PTGI consists of 5 subscales (relating to others; new possibilities; personal strength; spiritual change; appreciation of life) although it is possible to work with it as with a unidimensional measurement ($\Omega = .96$). The items are formulated as statements (e.g. „I changed my priorities about what is important in life.“) and participants use a 6-point scale to evaluate the extent to which they experienced change as a result of this traumatic event (from 0-5). A higher score indicates a higher level of growth.

The **International Trauma Questionnaire** (ITQ; Cloitre et al., 2018) measures 6 core PTSD symptoms following the diagnostic manual ICD-11 (e.g., re-experiencing avoidance, sense of current threat). The items are formulated as problems and the respondent evaluates how much the problem has bothered them during the last month on a 5-point Likert scale from 0-4 (0-Not at all; 1-A little bit; 2-Moderately; 3-Quite a bit; 4-Extremely). The construct can be divided into three clusters (avoidance; re-experiencing; a sense of threat) that represent the ICD-11 based on the probable PTSD ($\Omega = .91$).

Data analysis

From the total $N = 756$ patients, 60 patients were excluded due to missing data higher than 80%. In the effective sample ($N = 696$ patients), 1.4% missingness was found (missingness was examined in the measured variables). The average missingness in the PTSD symptoms and PTG indicators was 1.14% with the highest missingness of 2.16% being found in PTG indicator number 16 (“I put more effort into my relationships”). Pairwise deletion was used to deal with the missing data in computing the correlations and estimating the networks. Polychoric correlations were used for the correlation matrix.

A network approach was used to analyse the structure of PTG, PTSD and their interconnections (Epskamp et al., 2018). Through this approach, the relationships (edges) between individual symptoms, and indicators (nodes) are computed. The undirected weighted networks were also estimated. The strength of the relationship is represented by the thickness of the line and the direction of the relationship is given by a colour (e.g., red represents a negative relationship while blue represents a positive one).

Centrality indices (Constantini et al., 2015) were used to evaluate the importance and status of individual symptoms (indicators). These are a) strength, which quantifies the extent to which a node is directly connected to other nodes; b) closeness, which quantifies the extent to which a node is indirectly connected to other nodes; c) betweenness, which quantifies the average degree of importance of a node in relation to any other two nodes; d) expected influence is the summed weight of edges that it shares with the remaining nodes in the network. It takes negative associations into account, and represents the relative importance of the node in the network (Robinaugh et al., 2016).

The EBICglasso estimator method was used for the estimation of the networks. The bootstrapping method (nBoots = 2500) was used to check the stability of edges in the network structures, stability of the indices of centrality and by simulation, the stability and replicability of the estimated networks. The stability of correlations was examined by the correlation stability (CS) coefficient that indicates which proportion of persons could be eliminated from the analyses while retaining a correlation of at least 0.70. The CS-coefficient should not be below 0.25 and would preferably be above 0.50 (Epskamp et al., 2018). A bridge nodes analysis was used to analyse the bridging nodes that represent the interconnection between PTSD and PTG (Jones et al. 2017). For the bridge nodes, the same centrality indices were examined. Bridge nodes were chosen by the 80 percentile or higher on bridge strength. The brief version (10 items) of the PTG was used for better readability and interpretability for the PTG and PTSD network structure. A network analysis was carried out using the packages qgraph (Epskamp et al., 2012), bootnet (Epskamp et al., 2018), and networktools (Jones et al., 2017).

Peters et al. (2021) has suggested looking at PTSD-PTG connection groups with different levels of PTG. Accordingly, a latent class analysis was computed using the mclust package

(Scrucca et al., 2016) to find a group of cancer survivors with different levels of PTG. The difference between PTSD-PTG networks in these group of cancer survivors was examined using a network comparison test in the NetworkComparisonTest package (van Borkulo et al., 2019). This comparison will be presented in the sensitivity analysis part. All other analyses were computed by R statistical software (R Core Team, 2021).

Results

Sample

From the effective sample ($N = 696$), 463 patients with cancer were females. Most of them were married (57.6%) and had secondary school education (52.5%). The mean age of the cancer survivors was 53 ($SD = 15.44$) years old (range = 18-93) and about 62% had had cancer in their family history. The sample was heterogeneous from the perspective of the type of cancer (21 different types of cancer). The most prevalent diagnosis was breast cancer (211 cases), followed by colon cancer (61 cases), leukaemia (48 cases) and lymphoma (47 cases). About 5% (36 cases) had two or/and more types of cancer. The exact composition of the sample by cancer type can be found in the supplementary materials. The average time since being diagnosed with cancer was 6.48 years ($SD = 7.19$). About 21% of the cancer survivors had had one or more cancer relapses. During data collection, 181 cancer survivors were undergoing some type of treatment. Most of the cancer survivors (341 cases) had not had experience with a cancer support group while 114 cancer survivors regularly attended a cancer support group. More details can be found in the sample characteristics tables in the supplementary materials.

Descriptive analysis

Table 1 show the descriptive statistics of the analysed symptoms of PTSD and indicators of PTGI. The highest average value for the PTSD symptoms was found in the symptom *internal avoidance* while the highest average value for a PTG indicator was found in *better appreciation of each day*.

Table 1

Descriptive statistics of PTSD symptoms and PTG indicators

shortcut	symptom/indicator	M	SD	SE	Skewness	Kurtosis
PTSD						
Nightm	Upsetting dreams about cancer or something related to cancer	1.05	1.22	0.05	0.88	-0.40
Flash	Cancer-related flashback, reliving something related to cancer	1.45	1.27	0.05	0.41	-0.99
AvThought	Internal avoidance (thought, memories, feelings related to cancer)	1.54	1.33	0.05	0.35	-1.09
AvSit	External avoidance (people, places, activities, etc. related to cancer)	1.18	1.30	0.05	0.77	-0.63
Hyper	Being on guard	1.51	1.28	0.05	0.41	-0.93
Startl	Being jumpy (startled)	1.29	1.29	0.05	0.47	-0.91
PTG						
OTEOP	Count on people in times of trouble	3.32	1.52	0.06	-0.72	-0.46
CLOSE	Greater sense of closeness with others	2.80	1.63	0.06	-0.36	-1.01
EMOT	More willing to express emotions	2.60	1.64	0.06	-0.19	-1.16
COMP	More compassion for others	3.31	1.59	0.06	-0.77	-0.51
EFFORT	More effort into relationships	3.06	1.54	0.06	-0.55	-0.69
WOND	Learned about how wonderful people are	3.39	1.50	0.06	-0.81	-0.31
NEEDS	Accept needing others better	2.28	1.54	0.06	-0.53	-0.65
NINTER	Finding new interests	2.28	1.70	0.07	0.08	-1.26
PATH	New life path	2.13	1.67	0.06	0.14	-1.21
BETTR	Do better things with life	2.88	1.53	0.06	-0.38	-0.95
NOPP	New opportunities are available	2.40	1.62	0.06	-0.04	-1.11
CHANG	More likely to try and change things	3.09	1.53	0.06	-0.53	-0.69
SREL	Greater self-reliance	2.40	1.59	0.06	-0.04	-1.07
DIFF	Can handle difficulties better	3.04	1.54	0.06	-0.53	-0.71
ACCPT	Able to accept how things are going better	3.14	1.54	0.06	-0.62	-0.59
STGR	Discovered more strength	3.30	1.56	0.06	-0.73	-0.45
SPIR	A better understanding of spiritual matters	2.45	1.78	0.07	-0.05	-1.34
FAITH	Stronger religious faith	2.61	1.87	0.07	-0.17	-1.42
PRIOR	Changed life priorities	3.28	1.57	0.06	-0.67	-0.63
VALUE	Greater appreciation of value of own life	3.67	1.46	0.06	-1.03	0.15
APPR	Better appreciation of each day	3.72	1.46	0.06	-1.15	0.42

Note. PTSD symptoms are scored 0-4. PTSD was measure according to ICD-11. PTG indicators are scored 0-5.

Correlations and partial correlations

The average polychoric intercorrelation within the PTG indicators was .58 while it was .68 within the PTSD symptoms. The average polychoric correlation between PTG indicators and PTSD symptoms was .09, with the highest correlation of .30 being between *being on guard* (PTSD symptom) and *changed life priorities* (PTG indicator).

The average partial intercorrelation within the PTG indicators was .13 while it was .38 within the PTSD symptoms. The average partial correlation between PTG indicators and PTSD symptoms was .002, with the strongest positive correlation of .12 being between *being jumpy (startled)* (PTSD symptom) and *more compassion for others* (PTG indicator), and with the strongest negative correlation of -.15 being between *external avoidance* (PTSD symptom) and *more effort into relationships* (PTG indicator). For certain values of all polychoric and partial correlations see supplementary materials.

Network analysis

In Figures 1, 2 and 3, the estimated network structure of PTG, PTSD and PTSD-PTG are shown. The circles represent the nodes (symptoms or indicators) and specific PTSD symptom clusters, PTG indicator areas, and bridges nodes between PTSD and PTG are colour-coded. The lines represent edges (relationships between symptoms or indicators). The thickness of the lines represents the strength of the relationship (the thicker the line, the stronger the relationship). The colour of the lines represents the directionality of the relationships (blue represents a positive relationship while red represents a negative relationship). Figures related to the stability of edges, indices of centrality, stability and replicability of estimated networks can be found in the supplementary materials.

Figure 1 shows the network structure of PTG with indices of centrality. The PTG network was stable as indicated by the CS coefficients for edge weights, $CS (cor = .7) = .75$, for EI values, $CS (cor = .7) = .74$, and for Strength, $CS (cor = .7) = .59$. *Better understanding of spiritual matters and stronger religious faith, changed life priorities and greater appreciation of the value of one's own life, finding new interests and new life path* were all strongly positively related. The strongest positive relationships within the domain of the PTG indicators were found in the “relating to others” PTG domain. The most influential nodes in the PTG network were *putting more effort into relationships, ability to do better things with one's own life and greater sense of closeness with others*.

Figure 1 Network structure of PTG with centrality indices (strength and expected influence)

PTSD network structure

Figure 2 shows the network structure of PTSD with indices of centrality. The PTG network was stable as indicated by the *CS* coefficients for edge weights, *CS* ($\text{cor} = .7$) = .75, for EI and Strength values, *CS* ($\text{cor} = .7$) = .61, and for Closeness, *CS* ($\text{cor} = .7$) = .45. All three pairs of the PTSD symptoms within the PTSD symptoms clusters were strongly positively related. *Being on guard* was moderately strongly related to all other PTSD symptoms. The most influential symptoms in the PTSD network were *being jumpy or startled* and *cancer-related flashbacks*. *Cancer-related flashbacks* was also the symptom that was the most strongly indirectly related with other symptoms.

Figure 2 Network structure of PTSD with indices of centrality. Note. The index of strength and index of expected influence were both stable and had the same values, just one of them is displayed in the figure.

Bridge indicators (symptoms)

Figure 3 shows the network structure of PTG and PTSD with bridges nodes that link PTG and PTSD, and the bridge centrality indices. The PTG-PTSD network was stable as indicated by the *CS* coefficients for edge weights, $CS(\text{cor} = .7) = .75$, for EI values, $CS(\text{cor} = .7) = .64$, for Strength, $CS(\text{cor} = .7) = .65$, for BEI, $CS(\text{cor} = .7) = .65$, and for bridge Strength, $CS(\text{cor} = .7) = .42$. The most influential nodes in the PTSD and PTG connection were *being on guard or watchful* as a symptom of PTSD and *knowing better that one can handle difficulties* and *changing priorities about what is important in life* as the indicators of PTG.

Link between PTSD and Posttraumatic growth

Figure 3 Network structure of PTSD and PTG with bridges nodes representing the link between PTSD symptoms and PTG indicators

Sensitivity analysis

A two group solution according to latent class analysis was selected. One group with a low level of PTG (N = 284) and the second group with a higher level of PTG (N = 412). The most obvious difference between these groups was in “Greater appreciation of each day” and “Greater appreciation of the value of one’s own life” (Figure 4).

Figure 4 Latent group of cancer survivors based on a different level of PTG indicators

In these groups, the PTSD, PTG and PTSD-PTG networks with bridge nodes were estimated and compared. While the structure of PTSD did not differ from each other, the strength of the symptoms was significantly different. In the cancer survivors from the group with low PTG, the PTSD network was denser and the most influential symptom was “*Cancer-related flashbacks*”. In the group with the higher level of PTG, “*Being jumpy or startled*” was the most influential symptom. The PTG networks had significantly different structures. Finally, the PTSD-

PTG networks had different structures and also differed in the level of strength of certain nodes.

In these two groups, there were also different bridge nodes found. In the group of cancer survivors with a low level of PTG, *changing priorities about what is important in life, internal avoidance (thought, memories, feelings related to cancer)* and *upsetting dreams about cancer or something related to cancer* were the most influential nodes that linked PTSD and PTG. In the cancer survivors with a higher level of PTG, *knowing better that one can handle difficulties, being on guard or watchful*, and *upsetting dreams about cancer or something related to cancer* were the most influential bridging nodes. The only shared bridge node for both groups based on the different levels of PTG (Figure 5) was *upsetting dreams about cancer or something related to cancer*. The results regarding the comparison of networks can be found in the supplementary materials.

PTSD and PTG with bridge symptoms in patients with lower PTG

PTSD and PTG with bridge symptoms in patients with higher PTG

Figure 5 Network structure of PTSD and PTG with bridges nodes representing the link between PTSD symptoms and PTG indicators in a group of cancer survivors with low PTG ($N = 284$) and with a higher level of PTG ($N = 412$)

Discussion

The study aimed to explore the two most common posttraumatic reactions of posttraumatic stress disorder and posttraumatic growth as well as their relationship from the network perspective. A network approach could provide new insights into the understanding of posttraumatic reactions in cancer survivors.

PTG network

In the PTG network, *better understanding of spiritual matters* and *stronger religious faith*, *changed life priorities* and *greater appreciation of the value of one's own life*, *finding new interests* and *new life path* were the most strongly positively related. Other studies have also found a strong relationship between a better understanding of spiritual matters and stronger religious faith (Yuan et al., 2021; Peters et al., 2021; Bellet et al., 2018). Yuan et al. (2021) have found a strong relationship between a new life path and new interests as well. In contrast to previous studies, the current study has found that *changing life priorities* and a *greater appreciation of one's own life* was strongly related. This finding could be specific for cancer because cancer has a specific character (see e.g., Summala et al., 2009) in comparison to an acute trauma such as natural disaster or rape. In cancer, a person is continuously facing death (during treatment, regular hospital visits, etc.) and thus a person's perception of the value of their own life could be more intense and more strongly connected to changing overall life priorities. The most influential nodes in the PTG network were *putting more effort into relationships*, the *ability to do better things with their own life* and a *greater sense of closeness with others*. Peters et al. (2021) also found these last two PTG indicators to be the most influential. For cancer survivors, experiencing positive changes in the relationship with other people accompanied by feelings they can handle own life better, crucial for overall PTG, seem to be important. During counselling, the moments when cancer survivors begin talking about these things could be important for the facilitation of PTG. At these moments, it could be useful to focus interventions on other strong correlates of PTG as well.

PTSD network

In the current study, PTSD was conceptualized and measured as described in the ICD-11. Pairs of sense of threat, avoidance and re-experiencing symptoms were strongly related to each other which may indicate that these symptoms reinforce each other. Other studies focusing on the network structure of ICD-11 based PTSD have also found strong relationships within the symptoms in the avoidance and re-experiencing clusters (e.g., Gilbar, 2020; Levin et al., 2021; Glück et al., 2017). In these studies, the relationship between *startle response* and *hypervigilance* was not as strong as was found in the current study. However, Knefel et al. (2019) also found these symptoms to be strongly related. A strong relationship between the *startle response* and *hypervigilance* has even been found in the DSM-5 PTSD network studies (e.g., Guineau et al., 2021; Peters et al., 2021; Ross et al., 2018; Armour et al., 2017). This finding is also in line with the cognitive model of PTSD (Ehlers & Clark, 2000). In the current study, the *startle response or being jumpy* and *cancer-related flashbacks* were the most influential symptoms in the PTSD network structure. Cancer-related flashbacks was also the symptom that was most strongly indirectly related to other PTSD symptoms. This finding differs from most PTSD network studies (see Birkeland et al., 2020) in that hypervigilance has most often been found as a symptom with the highest strength. However, it is necessary to take into account that the ICD-11 PTSD network structure was analysed in the current study instead of the DSM-5 PTSD. To the best of our knowledge, ICD-11 PTSD network studies without the inclusion of ICD-11 symptoms of complex PTSD have not been done. This finding may also mean that the *startle response* is more influential than *hypervigilance* for PTSD development and maintenance in cancer survivors. Early identification of these symptoms could prevent the development of other PTSD symptoms. Interventions targeting these symptoms could alleviate the severity of PTSD in cancer survivors.

PTSD-PTG network

PTSD was linked with PTG through *being on guard or watchful* as a symptom of PTSD while *knowing better that one can handle difficulties* and *changing priorities about what is important in life* were the indicators of PTG. Hypervigilance and changing priorities have also been identified as bridge nodes in a sample exposed to a different type of trauma (Yuan et al., 2021). In a bereavement sample, Bellet et al., (2018) found changing priorities to be a bridge symptom connected to complicated grief and PTG. A higher level of a posttraumatic stress reaction may lead to the process of reassessing life priorities as the first step in triggering other parts of PTG. This is in line with the PTG theory where posttraumatic stress leads to shattering the core belief of a person (Tedeschi & Calhoun, 2004). It seems that this could happen through a higher level of hypervigilance which is directly positively related to changing life priorities. Being watchful can make a person not only more aware for threats but also other details in life, e.g., what is important and about what is not so important. The challenge to core belief was found to be the main predictor of PTG (Lindstrom et al., 2013). Another bridge node was *knowing better that one can handle difficulties*. *Knowing better that one can handle difficulties* was negatively weakly related to *external avoidance* and *cancer-related nightmares*. This indicates that some PTSD symptoms are negatively associated with PTG. It is difficult, if not impossible, to avoid certain cancer-related external reminders (e.g., hospital, physicians, cancer treatment) for cancer survivors. Avoidance of external reminders could lead to a lower sense that one can handling difficulties. On the other hand, it is almost impossible to have a higher level of external avoidance for cancer survivors as they continuously have to face reminders of trauma. The process of facing up to certain cancer-related external reminders could lower the level of external avoidance and raise knowing that one can handle difficulties. In addition, external avoidance was more strongly positively related to cancer-related nightmares, rather than internal reminders. A

lower level of external avoidance could also lead to a lower incidence of nightmares. The less frequent appearance of intrusive symptoms, such as nightmares, could also increase the sense of handling with difficulties. Some PTSD symptoms seem to be a trigger of PTG. According to PTG theory, experiencing a certain amount of distress is one of the key factors that enhances PTG development (Calhoun & Tedeschi, 2012).

PTSD-PTG network in the context of different levels of PTG

Peters et al. (2021) has suggested examining the PTSD structure based on different levels of PTG. In the current study, the PTSD-PTG network was looked at in a group of cancer survivors with lower and higher levels of PTG. By latent class analysis, we identified two groups of cancer survivors, with a lower and with a higher level of PTG. It was found that the PTSD-PTG networks were different in these groups, in terms of different structures, different levels of global strength centrality of certain nodes, and in the identified bridge symptoms. In both groups, one of the bridge symptoms was cancer-related nightmares. Yuan et al. (2021) have also found that nightmares is one of the bridging symptoms that link PTSD and PTG. Indeed, nightmares are one of the most intrusive and ruminative symptoms of PTSD. There are different types (e.g., intrusive, deliberative) of rumination which have been found to be related to PTG (Taku et al., 2009; Shigemoto, 2021). This highlights the importance of rumination symptoms in the process of PTG. For PTG in the context of cancer, the cancer-related positive and deliberative rumination is more important than the intrusive and negative rumination (Chan et al., 2011). For the cancer survivors with a lower level of PTG, the avoidance of cancer-related internal reminders and changing life priorities were the other most influential bridging nodes that link PTSD and PTG. For the cancer survivors with a higher level of PTG, the most influential nodes were hypervigilance and knowing better that one can handle difficulties. This demonstrates that PTSD and PTG could be connected differently based on the different levels of PTG. However, it

is necessary to interpret these findings with caution as the bridge centrality indices were not stable in the group of cancer survivors with a higher level of PTG.

Study limitations and future direction

The study has several limitations that should be mentioned. Due to the cross-sectional design of the current study, the causal relationships between nodes and the centrality of certain nodes, can be seen as hypotheses for a longitudinal study rather than definitive causal inferences. The longitudinal design could bring more valid inferences about the causality (Spiller et al., 2020), although some studies have written about the predictive value of centrality indices (e.g., Rodebaugh et al., 2018). In particular, posttraumatic reactions develop over time and the PTSD-PTG link could be better captured by measuring at several time points over a longer period. The PTSD and PTG structure could be different in people surviving different types of trauma. Thus, the current results are not possible to generalize to other populations other than cancer survivors. In addition, posttraumatic reactions and adaptation to cancer could be different based on culture and race. It would be necessary to compare with studies in a different culture. Another limitation is related to the BEI (Bridge Expected Influence) instability in the group of cancer survivors with the higher level of PTG. The stability of BEI in this group was under the minimum threshold level. A comparison of the PTSD-PTG network in groups with different levels of PTG should be examined in other research. Despite these limitations, the study brings new insight into posttraumatic reactions in cancer survivors from the network perspective.

Clinical Implications

Knowledge about PTSD and PTG on their symptoms (indicators) level, as well as their interconnection from the network perspective in cancer survivors, could be useful for the Positive Psychotherapy of Cancer (Ochoa et al., 2017). This is focused on facilitating posttraumatic

growth, assimilation and accommodation of traumatic experiences. Focusing on the processing of cancer-related intrusive symptoms may help transform intrusive rumination to deliberative rumination and by that facilitate growth. In addition, directing higher hypervigilance of cancer survivors from fear-like stimuli to another part of their life could help rebuild shattered core beliefs and subsequently rebuild life priorities. Greater support in handling cancer-related anxiety arousal and facing external reminders can strengthen knowledge that a person can handle difficulties better. These interventions may lead to enhancing PTG and reducing the symptoms of PTSD, thus facilitating constructive stress-growth balance (Ochoa Arnedo et al., 2019).

Conclusion

The current study extends the knowledge about posttraumatic reactions in cancer survivors from the network perspective. PTSD, PTG and PTSD-PTG networks show some similarities with other studies which have focused on network analysis of these phenomena. The most central symptoms in the ICD-11 PTSD in cancer survivors were the startle response and cancer-related flashbacks. The most influential indicators in PTG were putting more effort into relationships, feeling closer to other people and feeling more able to handle difficulties in life. PTSD and PTG are linked through hypervigilance, changing life priorities and being able to handle difficulties better although PTSD and PTG are connected by different bridge nodes in cancer survivors with different levels of PTG. In these groups, the PTSD and PTG networks were also different which supports the hypothesis from a previous study (Peters et al., 2021). Testing this hypothesis and looking at how PTSD and PTG are connected in persons with different levels of posttraumatic growth, are also needed in another type of trauma, ideally with a longitudinal design.

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