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Exploring Fear of Cancer Recurrence in Head and Neck Cancer Survivors: An Application of Computerized Text Analysis

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Research Article

Keywords: Fear of Cancer Recurrence, Cancer survivors, Linguistic Inquiry and Word Count (LIWC), Word Analysis

Posted Date: September 4th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10349754/v1

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Additional Declarations: No competing interests reported.

Abstract

Purpose

Fear of cancer recurrence (FCR) is a common psychological concern among cancer survivors and is often linked to post-traumatic stress, anxiety, and depression. This study used computational linguistic analysis to examine how linguistic markers in survivor interviews reflect psychological processes associated with FCR.

Methods

Twenty-two head and neck cancer survivors participated in semi-structured interviews after scheduled clinic visits. Transcripts were segmented and analyzed with the Linguistic Inquiry and Word Count (LIWC 2015). Only transcripts with a lexical capture rate above 75% were included in the text-mining analysis. Linguistic differences between the first and final thirds of the interviews were examined using the Shapiro–Wilk test, paired t-tests, and Wilcoxon signed-rank tests.

Results

Significant linguistic shifts occurred across the interviews. The use of emotion-related words, especially positive-emotion words, increased. Discrepancy words also rose, suggesting cognitive adjustment. Interpersonal markers, such as pronouns, social process words, and friend-related terms, increased notably. In contrast, physiology- and health-related terms decreased, reflecting a shift from bodily concerns to social and cognitive engagement.

Conclusions

These linguistic changes suggest a shift from body-focused distress to interpersonal engagement and cognitive reframing, indicating adaptive coping with FCR. Computational linguistic analysis may offer clinicians an objective, non-intrusive tool to identify survivors with persistent FCR-related psychological distress and to guide timely psycho-oncology referrals or supportive psychosocial interventions.

Implications for Cancer Survivors:

Integrating language-based assessment into survivorship care may improve understanding of emotional adjustment, support longitudinal monitoring of psychological adaptation, and enable personalized survivorship care.

Background

Cancer remains a major public health challenge in Taiwan, ranking among the leading causes of death despite advances in detection and treatment. However, improved survival rates have created significant psychosocial challenges. Fear of cancer recurrence (FCR) is the fear, worry, or concern that cancer may return or progress—it is among the most common and distressing of these challenges. Prevalent estimates range from 22% to 87% [1], with younger survivors at particularly high risk [2]. FCR negatively affects quality of life, leads to excessive health monitoring, avoidance behaviors, and emotional distress, and is associated with Post-Traumatic Stress Disorder (PTSD)-like symptoms in up to one-third of survivors [3]. Despite extensive research on FCR severity and predictors, less is known about how survivors' psychological processes unfold in naturalistic communication. A clearer understanding of the psychological mechanisms underlying FCR is therefore essential for developing effective interventions that promote long-term adjustment.

FCR is a multidimensional phenomenon encompassing existential concerns, cognitive uncertainty, emotional distress, and illness-related beliefs. Rather than examining these dimensions separately, the present study integrates four complementary theoretical frameworks—Terror Management Theory, Intolerance of Uncertainty, the Post-Traumatic Stress Model, and the Self-Regulation Model—to identify linguistic markers that reflect survivors' psychological adaptation and FCR coping processes. Because language provides a natural record of emotional and cognitive experiences, computational linguistic analysis offers a clinically relevant approach for examining how these processes are expressed in routine patient interviews.

These theoretical perspectives collectively suggest that FCR is reflected in identifiable linguistic patterns. Terror Management Theory and the Post-Traumatic Stress Model suggest that heightened mortality awareness, threat sensitivity, and intrusive thoughts contribute to FCR and are likely reflected in increased use of negative-emotion, health-related, body-focused, and avoidance-oriented language [4–9]. Conversely, adaptive meaning-making and post-traumatic growth are expected to be expressed through increased cognitive processing, positive emotions, and social affiliation, as well as clinically meaningful linguistic patterns and markers associated with better psychological adjustment [5, 8, 10]. Similarly, Intolerance of Uncertainty and the Self-Regulation Model emphasize that survivors' beliefs about recurrence and uncertainty influence emotional regulation and coping [11, 12]. Individuals with persistent FCR may use more uncertainty-, threat-, and self-focused language [13–15], whereas adaptive coping may be reflected in greater use of future-oriented, cognitive reappraisal, and interpersonal language [16].

Together, these frameworks offer a conceptual basis for examining linguistic markers as clinically meaningful indicators of survivors' psychological adaptation, potentially enabling earlier recognition of persistent FCR and timely psychosocial intervention. Although self-report questionnaires remain the standard for assessing FCR, they may not fully capture survivors' spontaneous emotional expression during clinical encounters. Linguistic analysis of naturally occurring speech may therefore provide complementary information to help clinicians recognize psychological distress, monitor changes in coping over time, and identify survivors who may benefit from psycho-oncology referral.

Language reveals underlying patterns: content words carry meaning, while function words (about half of everyday speech) signal attention and emotion [17–19]. The Linguistic Inquiry and Word Count (LIWC) program measures affective, cognitive, and social markers [20] and has been widely used in Taiwan [21, 22].

Cultural context shapes emotional expression and coping behaviors. Western narratives emphasize autonomy and individual control, whereas Asian contexts emphasize interdependence and relational harmony [23], which may lead to more restrained emotional expression. These cultural differences are particularly relevant to fear of cancer recurrence (FCR), as they may influence how survivors communicate uncertainty, bodily concerns, and coping strategies. This study, therefore, examined linguistic markers of FCR among Taiwanese head and neck cancer survivors using LIWC.

Understanding linguistic patterns in FCR is clinically relevant. By integrating Terror Management Theory, Intolerance of Uncertainty, Post-Traumatic Stress Model, and the Self-Regulation Model, we interpret interview data (Table 1) to demonstrate how language reflects evolving psychological states and informs culturally sensitive survivorship care. This study examined linguistic changes during semi-structured interviews with Taiwanese head and cancer survivors. Specifically, we aimed to identify changes in affective, cognitive, interpersonal, and physiological word use across the course of interviews and to examine whether these linguistic shifts align with theoretical models of FCR-related coping and psychological adjustment. Thus, we hypothesized that, as the interviews progressed, (a) positive-emotion and cognitive-processing (e.g., discrepancy) words would increase, reflecting emotional disclosure and cognitive adjustment. (b) health- and physiology-related words would decrease, reflecting reduced focus on bodily threat. (c) social and interpersonal markers would increase, indicating a shift toward greater relational orientation. Finally, by integrating computational linguistic analysis with survivor theory, this study aims to illuminate how psychological adaptation to FCR may be reflected in natural language.

Table 1
Inference on the Significant Performance of Text/words at Various Levels in the Fear of Cancer Recurrence (FCR) Process

Theory-oriented perspectives	Affective dimension	Behavioral dimension	Cognitive dimension	Interpersonal dimension
Terror Management Theory (TMT)	Positive emotion ↓ Negative emotion ↑		Achievement ↑	Self-reference ↑ Others-reference ↑ Religion-related ↑ Perception-process ↑
Intolerance of Uncertainty (IU)	Positive emotion ↓ Negative emotion ↑	Current-related narratives ↑ Future-related narratives ↓	Cognition-process ↑ Positive expectation state ↓ Negative expectation state ↑	Self-reference ↑
Post-Traumatic Stress Disorder (PTSD)	Positive emotion ↓ Negative emotion ↑		Cognition process ↓ Focus on the present tense↑ Focus on past tense↑ Physiological ↑	Self-reference ↑ Others-reference ↑ Perception-process ↑
Self-Regulation Model (SRM)	Negative emotion ↑		Cognition-process ↑	Friend ↑ Family ↑
Conclusion: As FCR↑, …	a. Positive emotion ↓ b. Negative emotion, especially fear and anxiety ↑ c. As PTG progresses, FCR↓, Positive, and Negative emotions ↓, then ↑	a. Current-related narratives ↑ b. Future-related narratives ↓	a. Cognition process ↑, as time passes ↓ b. Changes as PTG progresses c. Focus on future tense↑ and past tense↑; Focus on present tense↓ d. Achievement ↑; Physiological ↑	a. Self-reference ↑ b. Others-reference ↑ c. Religion, Friend, Family ↑ d. Perception-process ↑

ps.: 1. This table's word class names and classifications are based on the CLIWC compiled by Lin, W. F., Huang, C. L., Lin, Y. C., Lee, C. L., & Pennebaker, J. W. (2020). 2. ↑: increase; ↓: decrease

Methods

Design, Setting, and Participants

This qualitative study recruited head and neck cancer survivors from a tertiary hospital in northern Taiwan. Eligible participants were at least 20 years old, at least one year post-treatment, clinically stable, and able to communicate verbally. Exclusion criteria included recurrent disease requiring active treatment, dementia, or impaired cognitive function.

Ethics and Interview Procedures

The study was approved by the Institutional Review Board (No. 201901149B0) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants. Interviews were conducted in a private counseling room. They began with the open-ended prompt: “Could you describe your experiences since being diagnosed with cancer, receiving treatment, completing treatment, and your current life status?” Each interview lasted approximately 45–55 minutes. Interviews were audio-recorded, transcribed verbatim within 24 hours, and anonymized. The sample of 22 participants was considered appropriate for the exploratory aims of this study, based on qualitative and quantitative considerations. Previous methodological research suggests that stable linguistic patterns in relatively homogeneous interview samples typically reach saturation within 12–20 cases [24, 25]. Consistent with this recommendation, data saturation was achieved after 22 interviews, with no new stable linguistic markers identified during iterative analysis. In addition, the primary analyses used within-participant comparisons of linguistic markers across interview segments. This statistical approach is less sensitive to sample size limitations and has been shown to detect medium-sized effects with samples of approximately 20 participants [26, 27]. Nevertheless, the sample size limits the detection of small effects and the generalizability of findings, and results should therefore be interpreted as preliminary. Larger sample sizes are warranted in future studies to confirm and extend these findings across more diverse survivorship populations.

Contents of Interview Guide

A semi-structured interview guide was developed to explore survivors’ lived experiences across the diagnosis, treatment, and post-treatment phases, with particular emphasis on fear of cancer recurrence (FCR) and its psychological impact. The interview prompts invited participants to describe concerns about cancer recurrence, uncertainty about the future, emotional responses, coping behaviors and strategies, and perceived support needs throughout survivorship. These domains were selected because they represent core psychological dimensions of FCR and were intended to elicit narratives that reflect recurrence-related thoughts, emotions, and coping processes, rather than general survivorship experiences alone. The guide also explored how survivors interpreted their coping experiences and

psychological adjustment over time. The detailed structure and thematic domains of the interview guide are presented in Table 2.

Table 2
Semi-Structured Interview Guide

Stage	Main Semi-Structured Inquiry
Before Diagnosis	• When did you first notice that something was wrong? • What was happening at that time, and how did you feel physically and emotionally? • Looking back, what concerns or uncertainties did you experience before receiving the diagnosis?
At Diagnosis and Before Treatment	• How did you react when you learned your cancer diagnosis? • What thoughts and emotions came to mind? • Did you have any concerns or worries about your cancer coming back in the future? • How did you cope with these concerns? • How did you communicate your diagnosis and worries with your family?
During Treatment	• What treatments did you receive, and how did you respond physically and emotionally? • How did your concerns about recurrence change during treatment? • What helped you cope with fears or worries and move toward acceptance? • Who did you rely on for support during this period?
After Treatment	• How long has it been since you completed treatment? • What memorable experiences have you had during survivorship? • What is your follow-up routine? • What thoughts or emotions arise during follow-up visits? • Can you describe any concerns or worries you have about your cancer coming back? • How do these concerns affect your emotions, daily life, or future plans? • What helps you manage worries about recurrence?
End-of-Interview Reflection	• Looking back, how has your experience of cancer changed you? • How do you think about your future now?

Stage	Main Semi-Structured Inquiry
	• What support have you received, and what additional support would be helpful? • Who do you turn to when you feel worried about recurrence? • How have your illness and concerns about recurrence been discussed within your family, and how has this affected you?

Linguistic Inquiry and Word Count (LIWC) Tool

Language use was analyzed using the Linguistic Inquiry and Word Count (LIWC) program developed by Pennebaker and colleagues [19, 28, 29]. LIWC identifies linguistic markers associated with psychological processes, cognitive patterns, and emotional states. The software categorizes text into 30 linguistic and 42 psychological dimensions, comprising 72 word categories. The validated Chinese version of LIWC (CLIWC), developed by Huang et al. (2012), demonstrates strong equivalence with the LIWC 2007 version and high reliability in assessing Chinese linguistic and psychological expressions [30].

Words Analysis Procedure

Data processing followed established procedures described by Huang et al. (2012, 2022) and Wu et al. (2023). Verbatim transcripts were initially collected and processed using the Chinese word segmentation system developed by Academia Sinica [31, 32]. The segmented text was then imported into LIWC2015 [33] for quantitative linguistic analysis. To ensure data quality, only transcripts with a lexical capture rate above 75% were included. LIWC2015 was used to determine the relative frequency of psychologically meaningful word categories. Each transcript was divided into three equal segments, and linguistic markers from the first and final thirds were compared to examine changes in language use across the interview. Comparing the beginning and end of the interview was intended to capture potential shifts from initial disclosure of cancer-related concerns toward greater reflection, meaning-making, and psychological adaptation. The middle third was considered a transitional phase and was therefore excluded from the primary comparison.

Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics version 25 (IBM Corp., Armonk, NY, USA). Differences in word-category frequencies between the early and late interview segments were examined. Normality was assessed with the Shapiro–Wilk test. Paired t-tests were applied to normally distributed variables, and the Wilcoxon signed-rank test was used for non-normally distributed data. Statistical significance was set at $p < .05$. The analyses were intended to provide exploratory insights rather than definitive statistical inferences.

Results

Among the 22 survivors, 16 were men and 6 were women, with a mean age of 58.4 years (SD = 9.3). Twelve participants (54.5%) were diagnosed with nasopharyngeal carcinoma, and most (81.8%) had received concurrent chemoradiotherapy. The mean time since treatment completion was 3.25 years (SD = 1.89). Participant characteristics are summarized in Table 3.

Table 3
Demographic and Cancer-related characteristics(N = 22)

Demographic characteristics		**N (%)**	**Mean ± SD**	**Range**
Age (year)			58.36 ± 9.25	42–77
Gender	Male	16 (72.7)		
	Female	6 (27.3)		
Educational year			17.21 ± 3.26	12–24
Work status	No	10 (45.5)		
	Yes	5 (22.7)		
	Housekeeper	7 (31.8)		
Income	Yes	10 (45.5)		
	No	12 (54.5)		
Married status	Yes	20 (90.9)		
	No	2 (9.1)		
Religion	Yes	20 (90.9)		
	No	2 (9.1)		
Cancer-related characteristics				
Cancer Diagnosis	NPC	12 (54.5)		
	Non-NPC	10 (45.5)		
Concurrent Chemo-Radiotherapy	Yes	18 (81.8)		
	No	4 (18.2)		
Proton Therapy	Yes	4 (18.2)		
	No	18 (81.8)		
Times since finished treatment (years) [a]			3.25 ± 1.89	1–6
Chronic disease				
Hypertension [a]	Yes	9 (40.9)		
	No	11 (50.0)		
P.S. Four patients did not report the data.				

Demographic characteristics		N (%)	Mean ± SD	Range
Diabetes Mellitus	Yes	5 (22.7)		
	No	15 (68.2)		
Substance use				
Tabaco	No	11 (50.0)		
	Yes	11 (50.0)		
	Quit	8 (72.7)		
Betel nut	No	16 (72.7)		
	Yes	6 (27.3)		
	Quit	6 (100.0)		
Alcohol	No	11 (50.0)		
	Yes	11 (50.0)		
	Quit	10 (90.9)		
P.S. Four patients did not report the data.				

Significant linguistic changes were identified across the emotional, cognitive, interpersonal, and sensory-physiological domains. In the affective domain, the use of overall affective process words ($t = 2.54$, $p = .019$) and positive emotion words ($z = -2.91$, $p = .004$) increased significantly over the course of the interviews. However, no significant changes were observed in negative emotion, anxiety, anger, or sadness words. In the cognitive domain, discrepancy words increased significantly ($z = -3.98$, $p < .001$). An illustrative example is "I should be stronger" (Participant 10), reflecting awareness of the gap between survivors' current emotional experience and their desired coping or adjustment. In contrast, changes in causal, tentative, exact, and insight-related words were not statistically significant. In the behavioral domain, no significant differences were found in the use of past-, present-, or future-focused words, tense markers, or continuous tense forms.

In the interpersonal domain, overall pronoun use increased significantly ($t = 3.23$, $p = .004$). Significant increases were also observed in specific singular pronouns ($t = 2.73$, $p = .012$), indefinite pronouns ($z = -3.04$, $p = .002$), social process words ($t = 4.10$, $p = .001$), friend-related words ($z = -2.01$, $p = .044$), and second-person singular pronouns ($z = -3.22$, $p = .001$). An illustrative example of increased use of second-person singular pronouns is the statement, “You realize how fortunate you are, and you begin to see that you're actually doing well” (Participant 01). No significant changes were found in first- or third-person pronouns or in family-, male-, or female- terms.

In the **sensory-physiological domain**, the use of physiological words (t = -2.36, p = .028) and health-related words (t = -2.86, p = .009) decreased significantly. No significant changes were observed in perceptual, visual, auditory, body, sexual, and ingestion-related terms. Detailed results are presented in Table 4.

Table 4
Comparative Analysis of the Language Style of the First and Last Third of the Interview Contents

Dimension	Type of words	paired t-test		Wilcoxon signed-rank test	
		t	p	z	p
Affective	Affective process	2.54	.019*		
	Positive emotions			-2.91	.004**
	Negative emotions	0.94	.359		
	Anxiety			-0.73	.465
	Anger			-0.45	.651
	Sad			-0.44	.664
Behavioral	Tense Markers			-0.99	.322
	Focus on past tense	-0.36	.722		
	Focus on present tense.			-1.58	.115
	Focus on future tense.			-0.18	.858
	Continuous tense			-1.83	.068
Cognitive	Cognitive processes			-1.28	.200
	Insight			-1.51	.131
	Causation	-0.02	.988		
	Discrepancy			-3.98	< .001***
	Tentative	1.57	.131		
	Certainty	-1.51	.146		
	Difference			-0.13	.897
Interpersonal	Pronoun	3.23	.004**		
	Specific singular	2.73	.012*		
	First-person singular	1.56	.135		
	Second-person singular			-3.22	.001**
	Third-person singular	-0.64	.527		
	First-person plural			-1.15	.251
*** p < .001;** p < .01* p< .05					

Dimension	Type of words	paired t-test		Wilcoxon signed-rank test	
		t	p	z	p
	Second-person plural			-0.70	.484
	Third-person plural			-0.28	.776
	Indefinite			-3.04	.002**
	Social processes	4.10	.001**		
	Family			-0.73	.469
	Friends			-2.01	.044*
	Male			-1.89	.059
	Female			-1.17	.243
Sensory and	Perceptual processes	-0.93	.365		
Physiology	See			-0.37	.824
	Hear			-0.86	.390
	Feel			-1.87	.062
	Biological processes	-2.36	.028*		
	Body			-1.76	.079
	Health	-2.86	.009**		
	Sexual			-1.21	.225
	Ingestion			-0.31	.758
*** p < .001;** p < .01* p< .05					

Discussion

This study examined psychological changes in cancer survivors' verbal expression through linguistic analysis. The findings revealed notable shifts across the emotional, cognitive, interpersonal, and sensory-physiological domains. Specifically, affective process and positive emotion words increased over the course of the interviews. Discrepancy words increased in the cognitive domain. In the interpersonal domain, overall pronoun use—including specific singular, second-person singular, and non-specific pronouns—as well as social process and friend-related words, showed significant growth. In contrast, physiological and health-related words in the sensory-physiological domain decreased over time.

At the affective level, the increased use of emotion-related words suggests greater emotional expression as the interviews progressed. The rise in positive emotion words, together with stable negative emotion terms, may reflect increased attention to the positive aspects of survivors' experiences and possible adaptive emotional processing. Although such a pattern could represent efforts to buffer distress [18], emotional avoidance cannot be confirmed solely on linguistic grounds. The absence of changes in first-person pronoun use further suggests that these emotional shifts were not accompanied by increased self-focused language.

In the cognitive domain, the significant increase in discrepancy words (e.g., "should", "must") reflects stronger expressions of obligation and necessity, such as "stay positive" or "be strong". This pattern may indicate survivors' growing awareness of discrepancies between their perceived reality and ideal self-concept, reflecting cognitive processing of the gap between current experiences and desired psychological states, as expressed in statements such as "I wish..." or "I should..." [18]. Meanwhile, the stability of tense-related markers suggests that survivors' temporal focus on past, present, and future experiences remained relatively consistent.

Interpersonally, stable use of first-person pronouns suggests that survivors maintained consistent self-reference across interviews. Increased use of second-person and non-specific pronouns may reflect a shift toward broader, more generalized reflection. The use of the generic "you" suggests that survivors increasingly framed their experiences as shared and relatable rather than solely as personal distress, potentially reflecting cognitive adaptation and meaning-making. This pattern may also be influenced by the natural development of the interview interaction, as rapport-building may encourage participants to express their experiences in more general relational terms. Furthermore, increased use of social-process and friend-related words, alongside stable family-related terms, suggests greater engagement with broader social connections, particularly friendships, when coping with recurrence concerns and mortality-related thoughts; the specific relational functions of these terms require further investigation.

In the sensory-physiological domains, perception-related terms did not change significantly, indicating stable sensory descriptions throughout the interviews. However, the significant decline in the use of physiological and health-related words suggests a reduced verbal focus on bodily concerns. Because frequent use of health-related language has been associated with greater reporting of physical and mental symptoms [34], this decline may reflect a shift in coping. As survivors expressed growing discrepancies between their lived reality and ideal self, they may downregulate health concerns and avoid negative emotional material while emphasizing positive experiences. This linguistic pattern may represent an adaptive strategy for managing FCR.

Because the interview guide explicitly focused on recurrence concerns, uncertainty, coping, and survivorship experiences, the observed linguistic markers and patterns are likely to reflect FCR-related psychological processes rather than general emotional distress alone. Nevertheless, future research integrating standardized FCR assessments is needed to establish the specificity of these linguistic markers.

Clinical Implications

These findings highlight the potential utility of linguistic analysis as a complementary tool in survivorship care. Computational language markers may help clinicians identify survivors who remain highly focused on bodily threat, express heightened self-pressure related to discrepancy, or show limited emotional disclosure—patterns that may signal vulnerability to persistent FCR. For example, during survivorship consultations, triage nurses or oncology providers could use brief narrative prompts, such as asking survivors to describe their concerns about recurrence or their adjustment after treatment completion. Responses gathered through clinical interviews or digital health platforms could then be analyzed to provide additional insights into psychological processes and inform decisions about further psychosocial assessment or referral. With further validation, language-based assessment may complement existing FCR screening approaches and facilitate more personalized supportive care interventions.

Theoretical Contribution

By integrating Terror Management Theory, Intolerance of Uncertainty, the Post-Traumatic Stress Model, and the Self-Regulation Model, this study demonstrates how multiple FCR frameworks may converge in linguistic expression. Language appears to capture dynamic processes of meaning-making, relational orientation, and threat regulation that are not fully accessible through cross-sectional self-report scales alone. Computational text analysis may therefore extend traditional survivorship assessment by providing ecologically grounded indicators of psychological processing.

Limitations

Several limitations should be considered. First, the sample included only 22 participants, limiting the generalizability of the findings to the broader population of cancer survivors. The small number of female participants (n = 6) also precluded meaningful gender-based comparisons. Additionally, variability in cancer type, time since diagnosis, treatment modality, and family support levels may have influenced both linguistic patterns and psychological responses. Future studies with larger, more diverse samples are needed to address these factors. Although a validated FCR questionnaire was not administered, the semi-structured interview guide (Table 2) was specifically developed to elicit survivors' experiences related to cancer recurrence, uncertainty about the future, emotional responses, coping strategies, and survivorship concerns. These domains closely align with core theoretical dimensions of FCR. Therefore, the linguistic markers identified in this study are likely to reflect FCR-related psychological processes, although their associations with FCR severity could not be empirically confirmed. Future studies should combine linguistic analysis with validated FCR measures to establish criterion validity and further clarify the relationship between language use and FCR severity.

Despite these limitations, the findings align with theoretical perspectives that view FCR as a complex interplay of emotional, cognitive, and interpersonal processes. Linguistic analysis provides a non-

intrusive way to capture these dynamics and may help clinicians identify survivors who would benefit from additional psychological support.

Conclusion

This study demonstrates that linguistic patterns in cancer survivor narratives capture meaningful changes across emotional, cognitive, and interpersonal domains during clinical interviews. Increased use of positive emotion, discrepancy, and interpersonal language, together with fewer references to bodily experiences, suggests evolving psychological responses to fear of cancer recurrence (FCR). These findings suggest that natural language may capture dynamic processes in survivors' interpretation, regulation, and communication of FCR. Although these linguistic markers should not be interpreted as direct measures of psychological adaptation, they provide complementary insights into survivors' coping processes that may not be fully captured by standardized self-report measures alone.

Computational linguistic analysis has the potential to complement existing FCR assessment by helping clinicians identify survivors who remain highly focused on bodily threat, express elevated cognitive self-pressure, or demonstrate limited emotional processing during survivorship care. Integrating linguistic assessment with established FCR screening tools could enhance early identification of survivors who may benefit from targeted psychosocial interventions. Following further validation with standardized FCR measures and larger longitudinal cohorts, language-based assessment may support earlier psycho-oncology referral and contribute to more personalized, culturally responsive survivorship care.

Declarations

Conflict of interest:

The authors declare no conflicts of interest.

Author Contribution

• conception or design of the work; JT Chang, CH, Chang and CR Ling • acquisition, CR Ling; C Huang, YY Ke, ZQ Wang; TH Fang• analysis, C Huang • interpretation of data for the work: CR Ling, C Huang, JT Chang • Drafting the work: CR Ling • reviewing it critically for important intellectual content: CR Ling, CH Chang, JT Chang• Final approval of the version to be published and accountable for all aspects of the work: all authors

Acknowledgement

We thank the members of the Head and Neck Oncology Group at Chang Gung Memorial Hospital and Chang Gung University, Taoyuan, Taiwan, for their assistance

Ethics Statement

The study adhered to the ethical standards outlined in the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of Chang Gung Medical Foundation (IRB No.: 201901149B0). All participants provided informed consent prior to their inclusion in the study.

Clincial Trial Number: Clinical trial number: not applicable

Funding sources

This work was supported by a grant from the Ministry of Science and Technology (108-2314-B-182-009) of Taiwan's National Science and Technology Council.

References

1. Simard, S., et al., *Fear of cancer recurrence in adult cancer survivors: a systematic review of quantitative studies*. Journal of Cancer Survivorship, 2013. 7: p. 300–322.
2. Luigjes-Huizer, Y.L., et al., *What is the prevalence of fear of cancer recurrence in cancer survivors and patients? A systematic review and individual participant data meta-analysis*. Psycho-Oncology, 2022. 31(6): p. 879–892.
3. Leano, A., et al., *Are we missing PTSD in our patients with cancer? Part I*. Canadian Oncology Nursing Journal, 2019. 29(2): p. 141.
4. Willis, E., et al., *Testing terror management theory in advanced cancer*. Death Studies, 2023. 47(1): p. 65–74.
5. Barnes, S.J., *Understanding terror states of online users in the context of COVID-19: An application of Terror Management Theory*. Computers in human behavior, 2021. 125: p. 106967.
6. Koerner, N. and M.J. Dugas, *An investigation of appraisals in individuals vulnerable to excessive worry: The role of intolerance of uncertainty*. Cognitive therapy and research, 2008. 32: p. 619–638.
7. Abbey, G., et al., *A meta-analysis of prevalence rates and moderating factors for cancer-related post-traumatic stress disorder*. Psycho-Oncology, 2015. 24(4): p. 371–381.
8. Stockton, H., S. Joseph, and N. Hunt, *Expressive writing and posttraumatic growth: An Internet-based study*. Traumatology: An International Journal, 2014. 20(2): p. 75.
9. Pyszczynski, T., J. Greenberg, and S. Solomon, *A dual-process model of defense against conscious and unconscious death-related thoughts: an extension of terror management theory*. Psychological Review, 1999. 106(4): p. 835–845.
10. Kleim, B. et al., *Early linguistic markers of trauma-specific processing predict post-trauma adjustment*. Frontiers in psychiatry, 2018. 9: p. 645.
11. Koerner, N. and M.J. Dugas, *An investigation of appraisals in individuals vulnerable to excessive worry: The role of intolerance of uncertainty*. Cognitive therapy and research, 2008. 32: p. 619–638.

12. Leventhal, H., M.A. Safer, and D.M. Panagis, *The impact of communications on the self-regulation of health beliefs, decisions, and behavior*. Health Education Quarterly, 1983. 10(1): p. 3–29.
13. Song, J., et al., *Mediating effect of intolerance of uncertainty and cancer-related dysfunctional beliefs about sleep on psychological symptoms and fear of progression among cancer patients*. Psychiatry Investigation, 2023. 20(10): p. 912.
14. Guetto, R., G. Bazzani, and D. Vignoli, *Narratives of the future and fertility decision-making in uncertain times. An application to the COVID-19 pandemic*. Vienna Yearbook of Population Research, 2022. 20: p. 223–260.
15. Ankersmid, J.W., et al., *Relations between recurrence risk perceptions and fear of cancer recurrence in breast cancer survivors*. Breast cancer research and treatment, 2022. 195(2): p. 117–125.
16. Horwood, M., et al., *Illness perceptions, fear of cancer recurrence, and mental health in teenage and young adult cancer survivors*. Journal Of Pediatric Hematology/Oncology Nursing, 2024. 41(1): p. 44–55.
17. Ireland, M.E., et al., *Language style matching predicts relationship initiation and stability*. Psychological Science, 2011. 22(1): p. 39–44.
18. Chung, C. and J. Pennebaker, *The psychological functions of function words*, in *Social communication*. 2011, Psychology Press. p. 343–359.
19. Tausczik, Y.R. and J.W. Pennebaker, *The psychological meaning of words: LIWC and computerized text analysis methods*. Journal of language and social psychology, 2010. 29(1): p. 24–54.
20. Boyd, R.L. and H.A. Schwartz, *Natural language analysis and the psychology of verbal behavior: The past, present, and future states of the field*. Journal of Language and Social Psychology, 2021. 40(1): p. 21–41.
21. Wu, T.-Y., C. Huang, and T.-Y. Lin, *When Digital Deception is not the Extension of Real-life Deception: Computerized Text Analysis of Digital Deception in Day-to-day News*. Chinese Journal of Psychology, 2023. 65(3).
22. Huang, C., T.-Y. Wu, and Y.-L. Huang, *When I'm "Good", You Should Watch Out: Computerized Text Analysis of Linguistic Trajectory of Sexual Re-Offense*. Chinese Journal of Guidance & Counseling, 2022. 65: p. 1–25.
23. Jobson, L., et al., *Culture and the remembering of trauma*. Clinical Psychological Science, 2014. 2(6): p. 696–713.
24. Hennink, M.M., B.N. Kaiser, and V.C. Marconi, *Code saturation versus meaning saturation: how many interviews are enough?* Qualitative health research, 2017. 27(4): p. 591–608.
25. Guest, G., A. Bunce, and L. Johnson, *How many interviews are enough? An experiment with data saturation and variability*. Field methods, 2006. 18(1): p. 59–82.
26. Maxwell, S.E., H.D. Delaney, and K. Kelley, *Designing experiments and analyzing data: A model comparison perspective*. 2017: Routledge.

27. Lakens, D., *Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs*. Frontiers in Psychology, 2013. 4: p. 62627.
28. Pennebaker, J.W., M.E. Francis, and R.J. Booth, *Linguistic inquiry and word count: LIWC 2001*. Mahway: Lawrence Erlbaum Associates, 2001. 71(2001): p. 2001.
29. Pennebaker, J.W. and L.A. King, *Linguistic styles: language use as an individual difference*. Journal of personality and social psychology, 1999. 77(6): p. 1296–1312.
30. Lin, W.-F., C.-L. Huang, and Y.-C. Lin, *From LIWC to C-LIWC: The Potentialities of Computerized Chinese Word Count Analysis*. Journal of Taiwan Counseling Psychology, 2014. 2(1): p. 97–111.
31. Lin, W.-F., et al., *The Revision of the Chinese Linguistic Inquiry and Word Count Dictionary 2015*. Survey Research —Method and Application, 2020(5): p. 73–118.
32. Ma, W.-Y. and K.-J. Chen. *Introduction to the CKIP Chinese word segmentation system for the first international Chinese word segmentation bakeoff*. in *Proceedings of the second SIGHAN workshop on Chinese language processing*. 2003.
33. Pennebaker, J.W., Boyd, R.L., Jordan, K., & Blackburn, K, *The development and psychometric properties of LIWC2015*. Austin, TX: University of Texas at Austin, 2015.
34. Vine, V., R.L. Boyd, and J.W. Pennebaker, *Natural emotion vocabularies as windows on distress and well-being*. Nature Communications, 2020. 11(1): p. 4525.