Journal of Cancer Survivorship
https://doi.org/10.1007/s11764-022-01300-1

A latent class analysis of health behavior changes after cancer diagnosis among Hispanic/Latino cancer survivors

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Received: 14 September 2022 / Accepted: 10 November 2022

Abstract

Purpose We aimed to identify subgroups of Hispanic/Latino (H/L) cancer survivors with distinct health behavior patterns and their associated sociodemographic, medical, and psychosocial characteristics.

Methods Baseline data were used from a randomized clinical trial evaluating the efficacy of an enhanced patient navigation intervention in H/L cancer survivors. Participants ($n=278$) completed the Lifestyle Behavior Scale and validated questionnaires on health-related quality of life (HRQOL), supportive care needs, distress, and satisfaction with cancer care. Latent class analysis was used to determine the latent classes and associated characteristics.

Results Three latent classes emerged: class 1 (survivors who increased health behaviors [e.g., exercising and eating healthy] since diagnosis); class 2 (no changes in health behaviors since diagnosis); and class 3 (a "mixed class," with a higher or lower engagement across various health behaviors since diagnosis). Participants in class 1 were significantly more educated and less likely to be foreign born. Participants in class 2 were significantly older and more likely to have prostate cancer. H/L cancer survivors in class 3 had a significantly lower income, were less educated, and reported greater unmet supportive care needs, more distress, and poorer HRQOL.

Conclusions Survivors who report engaging in health behaviors less frequently since diagnosis may be experiencing psychosocial challenges and health disparities.

Implications for Cancer Survivors Hispanic/Latino cancer survivors may benefit from screening for social determinants of health and mental health needs, prompt referral to supportive care services, community resources, and public services, and participating in culturally informed psychosocial interventions to address their unique needs.

Keywords Cancer survivor · Health-related quality of life · Hispanics · Latent class analysis · Lifestyle behaviors

A diagnosis of cancer is considered a teachable moment and has the potential to trigger positive changes in health behaviors (e.g., exercising, eating healthy, avoiding alcohol) [1]. Cancer survivors who engage in multiple healthy behaviors are more likely to have greater survival rates and better health-related quality of life (HRQOL) [2, 3] likely due to

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Published online: 02 December 2022

their reduced risk of comorbidities (e.g., cardiovascular disease, diabetes) and increased sense of control over their lives [2, 4]. A meta-analysis found that recent cancer survivors (≤ 5 years after diagnosis) were more likely to adhere to multiple healthy behaviors, including maintaining a healthy weight and meeting recommendations for fruit and vegetable intake and physical activity, compared to long-term survivors (> 5 years) [5]. Notably, studies on adherence to multiple healthy lifestyle behaviors among cancer survivors have been conducted in the majority of White samples [5], with little representation from Hispanic/Latinos (H/Ls).

Cancer is the leading cause of mortality among Hispanic/Latinos in the USA, accounting for 20% of all deaths [6]. Compared to non-Hispanic Whites, Hispanic/Latinos are also more likely to be diagnosed with advanced disease, report poorer HRQOL, and have greater unmet psychosocial needs [7–9]. Previous studies have additionally identified important racial/ethnic differences in healthy lifestyle behaviors among cancer survivors. For example, in a large, population-based study where 6% of the sample identified as Hispanic/Latino ($n = 290$), Hispanic/Latinos had significantly higher adherence to fiber intake and alcohol recommendations but lower adherence to maintaining a healthy body mass index (BMI; < 25 kg/m2) compared to non-Hispanic Whites. Among prostate cancer survivors, the prevalence of physical inactivity was higher among Hispanic/Latino compared to non-Hispanic White men (43% vs. 30%) [10]. An important limitation of these and other previous studies is that health behaviors (and their associations with other variables of interest in a population) are typically examined in isolation from one another (a variable-centered approach) [11]. In contrast, person-centered approaches, such as latent class analysis (LCA), cluster individuals based on similar response patterns. Person-centered approaches may thus be used to examine multiple behaviors at the person level, classify individuals into distinct classes, and explore differences between classes on several variables of interest [12].

Hispanic/Latino cancer survivors' adherence to multiple healthy lifestyle behaviors may be explained by socioeconomic, cultural, and psychosocial factors. Yanez and colleagues developed a cancer-specific conceptual model to understand determinants of cancer-related outcomes (e.g., HRQOL) among Hispanic/Latinos [13]. This model posits that cultural (e.g., acculturation, nativity, documentation status) and socioeconomic (e.g., income, neighborhood) factors are interrelated and have an indirect impact on cancer outcomes through several modifiable and non-modifiable factors (i.e., psychosocial, behavioral, disease-specific, medical, and health care factors). For example, H/L breast cancer survivors are less likely to have health insurance, see a doctor due to cost, and have a check-up in the last year compared to non-Hispanic Whites [14]. In addition, previous studies examining the impact of acculturation on healthy lifestyle behaviors among US Hispanic/Latinos found that greater acculturation to US culture is associated with higher rates of smoking [15], sunbathing, and indoor tanning and lower rates of use of sun protective clothes [16]. Poor socioeconomic status can also adversely affect adherence to healthy lifestyle behaviors. Hispanic/Latinos living in lower socioeconomic neighborhoods have reduced access to supermarkets, recreational resources, and sidewalks, which may impact their ability to maintain a healthy diet and be physically active [17].

Overall, identifying subgroups of cancer survivors with distinct health behavior patterns and their associated sociodemographic, medical, and psychosocial characteristics may help researchers identify at-risk groups with similar health behavior patterns and, consequently, similar needs for behavioral interventions. This study aimed to identify (1) subgroups of Hispanic/Latino cancer survivors with distinct patterns of health behavior change after a cancer diagnosis and (2) their associated sociodemographic, medical, and psychosocial. The hypotheses are that (1) distinct subgroups of Hispanic/Latino cancer survivors will emerge based on their patterns of health behavior change and that (2) several sociodemographic, medical, and psychosocial characteristics will differentiate group membership.

Methods

Participants and procedures

The present study is a secondary analysis of a randomized controlled trial examining the efficacy of enhanced patient navigation through the Patient Navigation LIVESTRONG Cancer Navigation Services (PN-LCNS) program for improving HRQOL in Hispanic/Latino cancer survivors [18]. Briefly, eligible adults were those who (a) had a primary diagnosis of breast, prostate, or colorectal cancer; (b) completed active treatment within the past 15 months; (c) self-identified as Hispanic/Latino; and (d) were fluent in Spanish or English. In addition, participants were excluded if they (a) had evidence of distant metastatic disease; (b) had ongoing adjuvant therapy (i.e., chemotherapy, radiation); (c) reported active substance dependence problems within the past year; and (d) had current severe mental illness (e.g., psychosis) or active suicidal ideation. 1978 patients were prescreened via chart review from major tertiary medical centers in Chicago, IL, and San Antonio, TX. Of these, 60% ($n = 1179$) did not meet inclusion criteria. Of 799 remaining patients, 36% ($n = 288$) agreed to participate, 9% ($n = 73$) declined to participate, and 61% ($n = 438$) were excluded for other reasons (e.g., could not be reached for screening interview). After providing informed consent, participants ($n = 288$) completed the baseline assessment (T1) in English

or Spanish based on their language of choice. Later, participants were randomized 1:1 into the PN-LCNS or the patient navigation only (PN) condition. To guarantee equivalence of cancer types across conditions, randomization by disease site was done when two participants in the same disease type were identified at each study site (Chicago, IL, and San Antonio, TX). Participants also completed follow-up assessments at 3 (T2), 9 (T3), and 15 (T4) months post-baseline. For the purpose of this study, we used participants' baseline data.

Participants assigned to the PN-LCNS program received patient navigation services for 3 months, the LIVESTRONG Guidebook, the Health Journal, and the Care Plan. Additionally, participants had access to the phone-based LIVESTRONG Foundation's Cancer Navigation Services for the entire study, which helped to address emotional and financial concerns and provided education on cancer, treatment options, and fertility services. Participants assigned to the PN-only comparison condition received usual access to the traditional patient navigation services (maximum six phone calls) to seek information on cancer survivorship and available community services.

Measures

Lifestyle Behavior Scale

This 15-item scale was developed by the American Cancer Society Behavioral Research Center for the Study of Cancer Survivors-II (SCS-II) and measures health behavior changes after cancer diagnosis (e.g., exercising, eating healthy, using sunscreen, spending time with family and friends) [19]. Participants indicated if they had engaged in each of 15 behaviors "more," "less," or "the same amount" since their cancer diagnosis (Cronbach's $\alpha = 0.72$).

Sociodemographic and medical characteristics

Participants self-reported sociodemographic characteristics, including age, sex, marital status, country of origin, education, household income, acculturation, and language of preference. Acculturation was measured with the Short Acculturation Scale for Hispanics [20], a 12-item instrument used to assess US acculturation (e.g., English language use, English language media, and social relations). Items are rated on a 5-item Likert scale, and the responses can be averaged across items, where higher scores indicate greater acculturation to US culture (Cronbach's $\alpha = 0.93$). Data on cancer stage and treatment type (e.g., surgery, radiotherapy) were extracted from electronic medical records. Medical comorbidities were assessed with the Charlson Comorbidity Index [21]. The total score is a weighted sum of the number of existing conditions, wherein higher scores indicate greater medical comorbidity.

Health-related quality of life

The Functional Assessment of Cancer Therapy-General (FACT-G) scale was used to assess HRQOL [22]. This 5-point Likert scale instrument includes 27 items and yields four subscales (physical, social, emotional, and functional well-being) and a total score, with higher scores indicating better HRQOL (Cronbach's $\alpha = 0.91$).

Psychosocial adjustment

Cancer survivors' unmet needs was assessed with the Supportive Care Needs Survey [23]. This 5-point Likert scale instrument includes 34 items and yields five subscales: psychological, health system, physical and daily living, patient care and support, and sexuality (Cronbach's $\alpha = 0.97$). Psychological distress was assessed with a 10-item version of the Cognitive Somatic Anxiety Questionnaire [24]. Items are scored on a 5-point Likert scale, and a greater total score indicates higher distress (Cronbach's $\alpha = 0.86$). Patients' perceptions of the impact of cancer concerns on their daily functioning was measured with an adapted version of the Cancer-Specific Worry Interference questionnaire [25], which included seven items of this 5-point Likert instrument. A greater total score indicates higher worry interference (Cronbach's $\alpha = 0.89$). Participant's confidence in their ability to manage their cancer was assessed with the Chronic Disease Self-Efficacy Scale [26]. This 5-point Likert scale instrument includes 24 items and yields seven subscales, including patient-provider communication, social support, social/recreational activities, doing chores, managing physical symptoms, and controlling psychological distress (Cronbach's $\alpha = 0.78$–0.95). The Patient Satisfaction with Cancer Scale was used to assess patients' level of satisfaction on modifiable patient-centered cancer care practices, such as sufficient time with the physician, timely appointments, and patient inclusion in care decisions [27]. This 5-point Likert scale questionnaire includes 14 items, and a greater total score indicates a higher satisfaction level (Cronbach's $\alpha = 0.94$).

Statistical analysis

Model building and evaluation

First, we conducted a confirmatory factor analysis (CFA) with the items of the Lifestyle Behavior Scale to select high-quality indicators for the latent class analysis [28]. We used three fit indices for the evaluation of the CFA: comparative fit index (CFI ≥ 0.90), root mean square error of

approximation (RMSEA ≤ 0.05), and standardized root mean square residual (SRMR ≤ 0.08). The items related to avoiding alcohol and cigarettes led to poor fit indices, and they were not included in the current analysis. Therefore, we conducted an LCA with 13 items from the Lifestyle Behavior Scale (CFI, 0.971; RMSEA, 0.041; SRMR, 0.052). These items were getting regular checkups, taking vitamins, eating healthy foods, trying to lose weight, exercising, using sunscreen, avoiding exposure to the sun, wearing sun-protective clothing, getting rest, making efforts to control stress, spending time with family and friends, spending time on hobbies and recreation, and spending time on church or spiritual activities. LCA is a particular kind of mixture modeling where the observed variables are categorical and estimates latent class membership probabilities (i.e., the proportion of individuals in each class) and conditional item probabilities (i.e., the probabilities of engaging in each of the 13 behaviors "more," "less," or "the same amount" since their cancer diagnosis given their class membership) [29, 30]. We estimated several models, each with an increasing number of classes (i.e., estimating 2- to 5-class models). Then, we used a combination of fit indices to determine the optimal number of classes: Bayesian Information Criteria (BIC), sample-size adjusted Bayesian Information Criteria (SSABIC), entropy, Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR), and bootstrap likelihood ratio test (BLRT). Better model fit is indicated by lower values for the BIC and SSABIC. Significant VLMR and BLRT *p* values indicate that the *k* class model fit is significantly improved compared to the *k*-1 class model (e.g., the 3-class model fits better than the 2-class model). Entropy is measured on a zero to one scale, with higher values indicating greater classification accuracy [31]. In addition, class size was considered when determining the optimal number of classes. Classes containing less than 5% of the sample were considered spurious [32].

Examining differences among classes

After determining the number of classes, we examined significant differences in demographic, medical, and psychosocial characteristics. We applied the modified Bolck-Croon-Hagennars (BCH) method to evaluate significant differences across classes' continuous and categorical variables. The BCH method is the recommended method for examining relationships among classes and auxiliary variables [33, 34]. Auxiliary variables are covariates or predictors of group membership as well as distal outcomes (observed variables predicted by the latent class variable). The inclusion of these variables as auxiliary variables ensures that they do not play a role in the LCA model and do not affect the original latent class solution [33]. We performed the analysis in Mplus version 8.4. The sample size used for this analysis was 278 (97% of the participants who provided a response to the 13 items of the Lifestyle Behavior Scale). We used maximum likelihood with robust standard errors estimation for this analysis.

Results

Health behavior change classes

Fit indices for the models with two through five classes are shown in Table 1. Compared to the three-class model, the four-class model had a smaller sample-size adjusted BIC and greater entropy. Although the smallest class in the four-class model contained 13% of the sample, some of the classes showed overlapping patterns which made them difficult to interpret. Therefore, we selected the three-class model. The statistical criteria indicated that the three-class model had a better fit than the two-class model (i.e., lowest BIC, adj.

Table 1 Fit statistics for latent class analysis

Fit statistics	2 classes	3 classes	4 classes	5 classes
Latent class model				
BIC	6504.569	6485.558	6520.510	6577.744
SSABIC	6336.512	6231.887	6181.225	6152.845
Entropy	0.793	0.829	0.845	0.892
Adj. LMR-LRT (*p*-value)	165.92 ($p < .05$)	379.39 ($p < .05$)	116.23 (0.579)	94.09 (0.751)
Group size (*n*, %)				
Class 1	121, 43.5%	119, 42.8%	36, 13.0%	101, 36.3%
Class 2	157, 56.5%	60, 21.6%	59, 21.2%	21, 7.6%
Class 3		99, 35.6%	96, 34.5%	34, 12.2%
Class 4			87, 31.3%	93, 33.5%
Class 5				29, 10.4%

BIC Bayesian Information Criteria, *SSABIC* sample-size adjusted BIC, *Adj. LMR-LRT* sample-size adjusted Lo-Mendell-Rubin likelihood ratio test, *n* = class sample size

LMR p-value < 0.05). In addition, entropy was 0.829, which indicates clear class separation.

Participants in the first class predominately reported engaging in health behaviors "more" frequently since their cancer diagnosis across the 13 health behaviors assessed (42.8%, $n = 119$; Fig. 1). Participants in the second class predominately reported engaging in "the same amount" of health behaviors since their cancer diagnosis across the 13 health behaviors assessed (35.6%, $n = 99$). Finally, a third class included participants who reported engaging in health behaviors a combination of "less," "the same amount," or "more" since their cancer diagnosis (21.6%, $n = 60$). Participants in this class did not predominately report engaging in health behaviors "less" since their cancer diagnosis. However, this "mixed class" had a much higher endorsement of engaging in health behaviors "less" when compared to the first and second classes, specifically, in taking vitamins, eating healthy foods, trying to lose weight, using sunscreen, avoiding exposure to the sun, wearing sun-protective clothing, spending time with family and friends, spending time on hobbies and recreation, and spending time on church or spiritual activities.

Differences in sociodemographic and medical characteristics

Participant sociodemographic and medical characteristics are presented in Table 2 by class. Overall, participants had a mean age of 56.1 years (SE = 0.6). The majority were female (54%), Mexican (81%), married (62%), and reported a high school education or less (69%) and an annual income less than $50 K (68%). Regarding medical characteristics, participants were diagnosed with either breast (44.4%), prostate (31.3%), or colorectal (24.3%) cancer. The majority had either stage II or III (67%). In addition, participants had a mean Charlson comorbidity index of 3.5 (SE = 0.1).

Compared to those engaging in health behaviors "the same amount" since diagnosis, Hispanic/Latino cancer survivors who engaged in health behaviors "more" frequently since diagnosis were significantly younger ($p = 0.001$), more educated ($p = 0.04$), less likely to be foreign born ($p = 0.008$), and more likely to have breast cancer ($p = 0.010$). Hispanic/Latino cancer survivors in the "mixed class" had significantly a lower income, were less educated, and were less likely to be Catholic than those in the other two classes (all p's < 0.05). Participants engaging in health behaviors "the same amount" since diagnosis were significantly older and more likely to have prostate cancer than those in the other two classes (all p's < 0.05). In addition, participants engaging in health behaviors "the same amount" since diagnosis were significantly more likely to be male ($p = 0.049$), Catholic ($p = 0.019$), have a higher income ($p = 0.016$), and report more comorbidities ($p = 0.016$) compared to those in the "mixed class."

Differences in HRQOL and psychosocial characteristics

Participant psychosocial characteristics are presented in Table 3 by class. Hispanic/Latino cancer survivors who engaged in health behaviors "more" frequently since diagnosis reported significantly higher self-efficacy for getting health information than those engaging in health behaviors "the same amount" since diagnosis ($p = 0.048$). Hispanic/Latino cancer survivors in the "mixed class" reported significantly poorer overall HRQOL (including physical, emotional, and functional wellbeing) as well as greater unmet supportive care needs, more distress and worry interference, and lower self-efficacy for doing chores, participating in social activities, controlling depression, and managing symptoms than those in the other two classes (all p's < 0.05). There were no significant differences in patient satisfaction with care between classes.

Discussion

This study aimed to identify subgroups of recently diagnosed Hispanic/Latino cancer survivors with distinct health behavior patterns and their associated sociodemographic, medical, and psychosocial characteristics. In this study, we demonstrated the application of LCA to identify groups of Hispanic/Latino cancer survivors with distinct health behavior patterns. We identified three classes: Hispanic/Latino cancer survivors who engaged in health behaviors "more" frequently since diagnosis; those who engaged in health behaviors "the same amount" since diagnosis; and a "mixed class," with a higher or lower engagement across various health behaviors since diagnosis. In addition, we validated these classes in relation to a diverse set of correlates (e.g., income, education, and HRQOL indicators) and found that Hispanic/Latino cancer survivors who engaged in health behaviors "more" frequently since diagnosis were significantly more educated and less likely to be foreign born. Participants engaging in health behaviors "the same amount" since diagnosis were significantly older and more likely to have prostate cancer. Hispanics in the "mixed class" had a significantly lower income and were less educated.

We identified a group of Hispanic/Latino cancer survivors who engaged in health behaviors "more" frequently since diagnosis. For these individuals, cancer might have been perceived as a "teachable moment" and a trigger for health behavior change. These cancer survivors reported significantly better overall HRQOL (including physical, emotional, and functional wellbeing), greater levels of

Fig. 1 Response probabilities for the Lifestyle Behavior Scale items by classes

Table 2 Demographic and medical characteristics

	Overall $n=278$	Class 1 $n=119$	Class 2 $n=99$	Class 3 $n=60$	p (overall test)
Age, mean (SE)	56.1 (0.6)	54.6 (1.0)	59.3 (1.0)	53.7 (1.3)	$<0.001^{a,c}$
Female, *n* (%)	148 (53.2)	70 (58.8)	42 (42.4)	36 (60.0)	0.058^{c}
Intervention condition, *n* (%)	139 (50.0)	60 (50.4)	52 (52.5)	27 (45.0)	0.729
Married, *n* (%)	175 (62.9)	78 (65.5)	63 (63.6)	34 (56.7)	0.455
Catholic, *n* (%)	212 (76.3)	92 (77.3)	82 (82.8)	38 (63.3)	$0.061^{b,c}$
Income, *n* (%)					$0.018^{b,c}$
Less than $12,000	64 (23.0)	25 (21.0)	16 (16.2)	23 (38.3)	
$12,000–$24,999	75 (27.0)	31 (26.1)	28 (28.3)	16 (26.7)	
$25,000–$49,999	56 (20.1)	26 (21.8)	21 (21.2)	9 (15.0)	
$50,000 and greater	44(15.8)	23 (19.3)	15 (15.2)	6 (10.0)	
Education, *n* (%)					$0.001^{a,b,c}$
Less than high school	111 (39.9)	38 (31.9)	46 (46.5)	27 (45.0)	
High school diploma	81 (29.1)	41 (34.5)	22 (22.2)	18 (30.0)	
Associate/bachelor's degree	46 (16.5)	25 (21.0)	14 (14.1)	7 (11.7)	
Master/doctorate/professional	18 (6.5)	8 (6.7)	8 (8.1)	2 (3.3)	
Acculturation score, mean (SE)	2.4 (0.1)	2.4 (0.1)	2.3 (0.1)	2.4 (0.2)	0.468
Language, *n* (%)					0.680
Spanish only	156 (56.1)	63 (52.9)	61 (61.6)	32 (53.3)	
English only	49 (17.6)	20 (16.8)	17 (17.2)	12 (20.0)	
Bilingual (English and Spanish)	73 (26.3)	36 (30.3)	21 (21.2)	16 (26.7)	
Foreign born, *n* (%)	171 (61.5)	63 (52.9)	69 (69.7)	39 (65.0)	0.027^{a}
Years living in the US, mean (SE)	28.7 (1.1)	28.6 (1.7)	30.4 (1.8)	25.6 (2.3)	0.238
Country of origin, *n* (%)					0.934
Mexico	232 (83.5)	99 (83.2)	82 (82.8)	51 (85.0)	
Central America and Caribbean	22 (8.0)	9 (7.6)	7 (7.1)	6 (10.0)	
South America	19 (6.8)	8 (6.7)	8 (8.1)	3 (5.0)	
Cancer type, *n* (%)					$0.012^{a,c}$
Breast	121 (43.5)	61 (51.3)	29 (29.3)	31 (51.7)	
Prostate	89 (32.0)	31 (26.1)	43 (43.4)	15 (25.0)	
Colon	68 (24.5)	27 (22.7)	27 (27.3)	14 (23.3)	
Stage, *n* (%)					0.653
0	6 (2.2)	2 (1.7)	2 (2.0)	2 (3.3)	
I	55 (19.8)	26 (21.8)	20 (20.2)	9 (15.0)	
II	98 (35.3)	39 (32.8)	36 (36.4)	23 (38.3)	
III	72 (25.9)	27 (22.7)	27 (27.3)	18 (30.0)	
Months since treatment ended, mean (SE)	5.0 (0.8)	4.6 (0.4)	5.7 (0.5)	4.7 (0.6)	0.228
Surgery, *n* (%)	233 (83.8)	101 (84.9)	81 (81.8)	51 (85.0)	0.106
Radiotherapy, *n* (%)	158 (56.8)	72 (60.5)	49 (49.5)	37 (61.7)	0.120
Neoadjuvant chemotherapy, *n* (%)	43 (15.5)	15 (12.6)	15 (15.2)	13 (21.7)	0.320
Adjuvant chemotherapy, *n* (%)	87 (31.3)	40 (33.6)	24 (24.2)	23 (38.3)	0.097
Comorbidity Charlson score, mean (SE)	3.5 (0.1)	3.3 (0.2)	3.9 (0.2)	3.2 (0.2)	0.040^{c}

Class 1, engaging in health behaviors "more" frequently since their cancer diagnosis; class 2, engaging in health behaviors "the same amount" since diagnosis; class 3, "Mixed" class. Significant p value <0.017
a = class 1 vs. 2, b = class 1 vs. 3, c = class 2 vs. 3

self-efficacy, and lower levels of distress than those in the "mixed class." These findings support the positive association between psychosocial factors and health behaviors, where positive health behaviors, such as engaging in physical activity, are consistently associated with better psychological, emotional, and physical well-being among cancer survivors [2].

Individuals who engaged in health behaviors "the same amount" since cancer diagnosis were more likely to be older, have prostate cancer, and more comorbidities. Given that

Table 3 Mean and standard errors for psychosocial characteristics as a function of latent classes

	Overall $N=278$	Class 1 $N=119$	Class 2 $N=99$	Class 3 $N=60$	p (overall test)
FACT-G (sum score)	80.4 (1.0)	83.3 (1.5)	82.8 (1.6)	71.1 (2.4)	$<0.001^{b,c}$
Physical well-being	22.5 (0.3)	23.1 (0.5)	24.2 (0.6)	18.9 (0.8)	$<0.001^{b,c}$
Social well-being	18.9 (0.3)	19.8 (0.5)	18.7 (0.6)	17.5 (0.8)	0.071^{b}
Emotional well-being	19.5 (0.3)	20.2 (0.4)	19.9 (0.5)	17.5 (0.6)	$0.001^{b,c}$
Functional well-being	19.5 (0.3)	20.3 (0.5)	19.9 (0.6)	17.3 (0.8)	$0.010^{b,c}$
SCNS (sum score)	27.1 (1.3)	24.4 (2.2)	22.6 (2.2)	38.8 (2.8)	$<0.001^{b,c}$
Psychological	22.8 (0.7)	20.8 (1.0)	21.3 (1.2)	28.9 (1.4)	$<0.001^{b,c}$
Health system and info	23.4 (0.7)	22.7 (1.1)	21.3 (1.2)	28.3 (1.5)	$0.001^{b,c}$
Patient care and support	9.4 (0.3)	9.4 (0.5)	8.1 (0.5)	11.4 (0.7)	$<0.001^{b,c}$
Physical and daily living	9.4 (0.3)	9.4 (0.5)	8.1 (0.5)	11.4 (0.7)	$<0.001^{b,c}$
Sexuality	6.7 (0.2)	5.9 (5.9)	6.7 (0.4)	8.2 (0.5)	$0.003^{b,c}$
Level of distress	16.2 (0.4)	15.8 (0.6)	14.4 (0.6)	19.8 (1.2)	$0.001^{b,c}$
Worry interference	13.5 (0.4)	12.4 (0.6)	11.9 (0.6)	17.9 (1.0)	$<0.001^{b,c}$
Self-efficacy (mean score)					
Get information	4.3 (0.1)	4.4 (0.1)	4.1 (0.1)	4.1 (0.2)	0.070^{a}
Obtain help from friends and family	3.8 (0.1)	3.8 (0.1)	3.9 (0.1)	3.8 (0.1)	0.415
Communicate with physician	4.3 (0.1)	4.3 (0.1)	4.3 (0.1)	4.2 (0.1)	0.622
Do chores	3.9 (0.1)	4.1 (0.1)	4.0 (0.1)	3.5 (0.2)	$0.003^{b,c}$
Social activities	3.8 (0.1)	4.0 (0.1)	4.0 (0.1)	3.2 (0.2)	$<0.001^{b,c}$
Control depression	3.8 (0.1)	4.0 (0.1)	3.9 (0.1)	3.4 (0.1)	$0.002^{b,c}$
Manage symptoms	3.8 (0.1)	4.0 (0.1)	3.8 (0.1)	3.4 (0.1)	$0.004^{b,c}$
Patient satisfaction with care	54.4 (0.5)	55.3 (0.8)	53.0 (0.9)	55.1 (0.9)	0.134

FACT-G Functional Assessment of Cancer Therapy-General, *SCNS* Supportive Care Needs Survey. Class 1, engaging in health behaviors "more" frequently since their cancer diagnosis; class 2, engaging in health behaviors "the same amount" since diagnosis; class 3, "mixed" class. Significant p value <0.017 a = class 1 vs. 2, b = class 1 vs. 3, c = class 2 vs. 3

chronic diseases are generally more common among the elderly, a possible explanation for these findings might be that these individuals were already coping with other chronic diseases by the time of their cancer diagnosis and may have thus already been engaging in healthy behaviors to improve their health and well-being [35]. They may also interact with health care providers more regularly [36] and thereby have increased opportunities for learning about healthy lifestyle behaviors. Because data on their pre-cancer health behaviors were not collected; however, we cannot be certain that these individuals were already engaged in healthy behaviors before their cancer diagnosis and that their behaviors remained unchanged following their cancer diagnosis (as is desired). Another possibility is that because older cancer survivors experience more significant functional and cognitive impairment when compared with younger cancer survivors, they may encounter more challenges changing their existing healthy behaviors (e.g., physical activity) [37]. Previous studies have noted that prostate cancer survivors are less likely to make healthy lifestyle changes than other cancer survivors [38] which may be explained by the fact that prostate cancer treatment (e.g., endocrine therapy, surgery) can lead not only to debilitative side effects and impaired physical and cognitive functioning [39] but also to profound psychological effects (e.g., loss of masculinity, poor self-esteem) [40], which could reduce their ability or willingness to engage in positive behavior change.

Participants in the "mixed class" had a lower income and were less educated than those in the other two classes. Among Hispanic/Latino cancer survivors, low socioeconomic status and educational attainment are associated with worse cancer morbidity, mortality, and HRQOL outcomes [13]. These sociodemographic differences are also consistent with previous studies examining lifestyle behaviors in cancer survivors, where low education level reduces the odds of making positive behavior changes [40]. Screening for social determinants of health and ensuring referral and linkage to community resources and public services may significantly improve the health and quality of life of Hispanic cancer survivors [41]. Additionally, individuals in this group reported greater unmet supportive care needs, more distress and worry interference, and poorer HROQL. A previous study found that Hispanic/Latino cancer survivors reported greater needs for information (e.g., gaining knowledge on cancer and symptom management), practical assistance (e.g., transportation, family care), emotional

support (e.g., stress management), and spiritual resources (e.g., finding meaning and hope) than non-Hispanic whites [8]. Unmet psychosocial needs have been associated with lower HRQOL and higher symptom burden among Hispanic/Latino cancer survivors [42, 43]. Thus, developing culturally informed psychosocial interventions to address these needs are vital. Participants in this class also reported lower self-efficacy for daily activities and symptom management. These findings are in line with previous research that has identified cancer-relevant self-efficacy as a predictor of symptom burden, cancer-specific distress, and functional, emotional, and social well-being among Hispanic breast cancer survivors [44]. Given that individuals with greater self-efficacy are more likely to adopt new health behaviors [45], future interventions should target self-efficacy as a mechanism to adopt healthy behaviors. Potential ways to enhance self-efficacy in Hispanic/Latinos include improving health literacy [46, 47], setting goals [48], providing instrumental support [49], and health coaching [50].

Although we did not find significant differences between classes in acculturation levels, language of preference, country of origin, and years living in the USA, a smaller proportion of participants who reported engaging in health behaviors "more" frequently since diagnosis were foreign born compared to those who engaged in health behaviors "the same amount" since diagnosis. The reported effects of nativity on health behaviors among Hispanic/Latinos are mixed. A study found that foreign-born cancer survivors living in the USA < 10 years were less likely to engage in aerobic physical activity compared with second and higher-generation (US-born) Hispanic/Latino cancer survivors [51]. Foreign-born Hispanic/Latinos have reported higher fruit and vegetable consumption [52] as well as lower rates of smoking and obesity than their US-born counterparts [53]. Acculturation is a complex phenomenon, and place of birth, language of preference, socioeconomic status, and length of stay in the USA may contribute to different effects on health behaviors and cancer outcomes among Hispanic/Latinos. As such, future studies on lifestyle behaviors among Hispanic/Latino cancer survivors should collect information to provide additional insights into these relationships.

The current study expands our understanding of adherence to multiple healthy behaviors among Hispanic/Latino cancer survivors. Findings from this study highlight the importance of assessing sociodemographic, medical, and psychosocial characteristics when working with Hispanic/Latino cancer survivors (e.g., age, comorbidities, income) as these factors may help identify at-risk cancer survivors in need for interventions to improve their health behaviors. However, study findings should be interpreted in light of several limitations. First, the use of cross-sectional data permits conclusions to be drawn regarding associations, but causal inferences may not be made. Longitudinal studies are needed to improve our understanding of health behavior changes made after cancer among Hispanic cancer survivors and their sustainability over time. In addition, future studies should consider the inclusion of Hispanic cancer survivors with any cancer type. Lastly, these results should be interpreted with caution because they are limited in generalizability (i.e., primarily Mexican American cancer survivors). Although the percentage of Mexicans/Mexican Americans is representative of Hispanics in the USA as a whole, there is significant regional variability in the US Hispanic/Latino population (e.g., Cubans in South Florida, vs. Mexicans and Puerto Ricans in the Midwest). Therefore, a larger sample with more diversity in country of origin would allow for a more nuanced examination of within-group differences.

Conclusions

Findings from the current study suggest that Hispanic/Latino cancer survivors who have lower income, less education, worse HRQoL, and greater distress and unmet supportive care needs are less likely to increase healthy behaviors following their cancer diagnosis. Strategies to optimize health after cancer diagnosis for H/L cancer survivors may include timely screening for social determinants of health and mental health needs, prompt referral to supportive care services, community resources and public services, and access to culturally informed psychosocial interventions.

Author contribution Blanca S. Noriega Esquives: writing—original draft, writing—review and editing, data curation, and formal analysis. Sara M. St. George: writing—original draft, writing—review and editing. Patricia I. Moreno: writing—original draft, writing—review and editing. Tae Kyoung Lee: writing—original draft, writing—review and editing, and formal analysis. Edgar Munoz: data curation, writing—review and editing. Thomas Lad: writing—review and editing. Alan Pollack: writing—review and editing. Courtney M.P. Hollowell: writing—review and editing. Amelie G. Ramirez: conceptualization, funding acquisition, investigation, methodology, project administration, resources, supervision, validation, and writing–review and editing. Frank J. Penedo: conceptualization, funding acquisition, investigation, methodology, project administration, resources, supervision, validation, and writing–review and editing. All authors read and approved the final manuscript.

Funding This research was supported by the National Cancer Institute (U54CA153511 awarded to Amelie G. Ramirez and Frank J. Penedo), the Mays Cancer Center at University of Texas Health San Antonio (P30CA054174), and the Robert H. Lurie Comprehensive Cancer Center at Northwestern University (P30CA060553).

Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee (Institutional Review Board) of each institution.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Competing interests The authors declare no competing interests.

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