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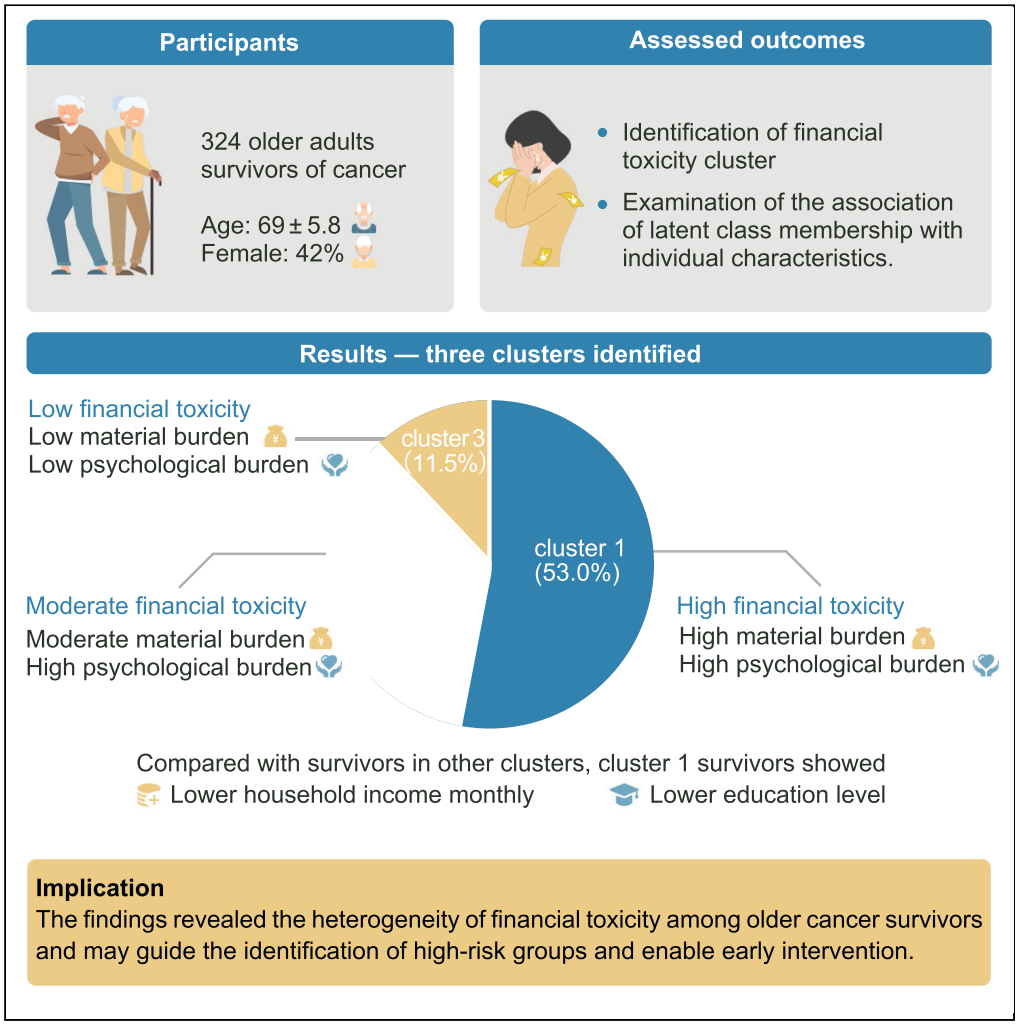

Mingzhu Su, Siqi Liu, Li Liu, Fang Wang, Jiahui Lao, Xiaojie Sun

xiaojiesun@sdu.edu.cn

Highlights

Financial toxicity is prevalent in older Chinese cancer survivors

Heterogeneity in financial toxicity allows three profiles to be distinguished

Age, household income, education level, and living alone may affect profile

Policies and interventions to mitigate financial toxicity are essential

Su et al., iScience 26, 107768
October 20, 2023
https://doi.org/10.1016/j.isci.2023.107768

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Heterogeneity of financial toxicity and associated risk factors for older cancer survivors in China

Mingzhu Su,[1,2,7] Siqi Liu,[3,7] Li Liu,[4,5] Fang Wang,[3] Jiahui Lao,[6] and Xiaojie Sun[1,2,8,*]

SUMMARY

In China, older cancer survivors may show heterogeneity in financial toxicity (FT). We aimed to identify FT profiles among older Chinese cancer survivors and examine the association between FT profiles and individual characteristics. We used a latent profile analysis to categorize participants and a multinomial logistic regression to examine the associations. We identified three distinct FT profiles: high, moderate, and low. Participants aged 65–69 years, with a monthly household income $\geq$ 5,000 CNY and a high school education or above were more likely to be classified into the moderate than high FT profile, a monthly household income $\geq$ 5,000 CNY increased the likelihood of being in the low FT profile and living alone negatively affected the odds of being in the low FT profile. The findings identified heterogeneity in FT among this population, may help identify high-risk groups, and may enable early intervention.

INTRODUCTION

The cancer survival rate has increased globally with the recent surge in innovative treatments, early diagnosis, and treatment access.[1] However, advancement comes with a higher cost. For instance, anticancer drug expenditure worldwide increased from US$96 billion in 2016 to US$185 billion in 2021 and is expected to exceed US$300 billion by 2026.[2] Individuals with cancer may have to endure out-of-pocket (OOP) costs and income loss for cancer diagnosis and treatment.[3] The term "financial toxicity" (FT) has been used to define the financial burden and financial distress that may negatively affect the well-being of patients, such as those who are unable to pay for treatment and often have to dip into their savings, change their lifestyle, borrow money to pay for treatment, or declare bankruptcy.[4–7] Such burdens and distress have come to be regarded as a new type of side effect in oncology due to their potential to impact patient outcomes, including health-related quality of life,[8,9] symptom burden,[10] treatment adherence,[11,12] and most recently, survival.[13]

According to data from GLOBOCAN, China has 4.57 million new cancer cases and 3 million deaths from cancer per year, accounting for 24% of newly diagnosed cases and 30% of cancer-related deaths globally. Moreover, it is experiencing unprecedented growth in the number of older patients diagnosed with and surviving cancer owing to its historically large older adult population and fastest rate of aging worldwide.[14–16] At present, older adults are estimated to constitute more than 60% of newly diagnosed cancer cases and 70% of cancer deaths in China.[1,17] Moreover, because of their impaired physical and cognitive functions and accelerated rate of comorbidity, older cancer patients are generally treated with more drugs and for longer treatment cycles. Consequently, they may be more vulnerable to FT than younger cancer patients.[18] It is well known that health insurance coverage plays a key role in easing the financial burden of cancer survivors and their families. As of 2022, more than 95.0% of Chinese residents were covered under a basic insurance scheme by either Urban Employee Basic Medical Insurance (UEBMI) or Urban and Rural Residents Basic Medical Insurance (URRBMI).[19,20] However, public-funded cancer coverage schemes provided to this sector of the population only include a limited set of personalized tumor therapies and medical assistance, leading to high OOP costs and an increased economic burden.[7] In addition, approximately 44% of older cancer survivors in China had to borrow money for their diagnosis and treatment.[21] Moreover, due to the limited availability of pensions and social protection schemes, adults with cancer, especially older adults, are both physically and financially dependent on their families, which means that the FT of cancer generates a compounding effect in which the economic stability, productivity, and income of entire generations may also be affected.[22]

The wide-reaching implications of FT among cancer survivors have been discussed using variable-centered approaches.[18,23–26] For example, FT has been divided into quartiles such as none, low, moderate, and high, according to distributions of samples for detecting threshold effects on financial well-being.[25,27] Others have divided FT into low, moderate, and high groups based on the total scores below

[1]Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine, Shandong University, Jinan, Shandong 250012, China
[2]NHC Key Lab of Health Economics and Policy Research (Shandong University), Jinan, Shandong 250012, China
[3]Center of Health System and Policy, Institute of Medical Information & Library, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing 100020, China
[4]School of Nursing and Rehabilitation, Cheeloo College of Medicine, Shandong University, Jinan, Shandong 250012, China
[5]Shandong Provincial Hospital Affiliated to Shandong First Medical University, Jinan, Shandong 250021, China
[6]Center for Big Data Research in Health and Medicine, The First Affiliated Hospital of Shandong First Medical University & Shandong Provincial Qianfoshan Hospital, Jinan Shandong, China
[7]These authors contributed equally
[8]Lead contact
*Correspondence: xiaojiesun@sdu.edu.cn
https://doi.org/10.1016/j.isci.2023.107768

or above the mean FT[28,29] or have divided the groups on the basis of the median score.[23] However, human aging in modern society is characterized by an obvious inter-individual variability in clinical and demographic characteristics, disease burdens, cognitive and functional capacities, and social conditions. Previous analyses have been based on the relationships between variables and simply assumed that the sample under study was homogeneous, without considering the possibility that these relationships may vary from factor to factor. Older cancer survivors' FT may not be the homogeneous construct that the traditional variable-centered approach has assumed. Rather, they may be clustered into unobserved distinct subgroups with large differences across the population. In other words, patients may be similar within a group but vary across groups relating to FT measures. There are still no studies on the heterogeneity of FT among older cancer survivors, leading to a gap in understanding FT categories.

Latent profile analysis (LPA), a person-centered algorithm, could identify model heterogeneity by classifying latent subpopulations within populations.[30] LPA makes it possible to illustrate internal relationships with indiscrete manifest variables and class individuals into common profiles.[31] Theoretically, subgroups of older cancer survivors may exist in terms of their different FT levels. The present study used LPA to identify *a priori* unknown distinct latent profiles of cancer survivors based on FT measures. Once latent profiles were identified, a logistic regression model was used to analyze the association of the latent class membership with individual characteristics. The study findings may help clarify disparities in FT of older cancer survivors and inform targeted interventions for cancer survivors in different FT subgroups.

RESULTS

Individual characteristic distribution and COST value status

For all participants (N = 324), the mean Comprehensive Score for Financial Toxicity (COST) value was 12.6 (standard deviation; SD = 9.8) and the median COST value was 11.0. Approximately one-third were aged 65–69 years (33.0%), and more than half (58.0%) were female. The majority were married (93.2%). The household monthly income of 26.2% of participants was below 1,000 CNY (approximately US$ 150), 50.0% were retired, 32.1% had an education level of high school or above, 57.7% were covered by URRBMI, and only 24.7% lived alone. Regarding clinical information, patients with lung cancer accounted for the largest proportion (49.4%). More than half of the participants were in cancer stages III or IV (52.5%), the majority had been diagnosed within one year (63.6%), and 49.7% reported that they had no other chronic diseases. The detailed data and COST values are shown in Table 1.

Latent profile analysis for financial toxicity

Models with one through four profiles (k = 1–4) were compared to identify the optimal number of profiles (see Table 2). Model selection was based on an examination of the most commonly recommended statistical model fit criteria at the time. As shown, a four-profile model may be appropriate according to the lowest values of the Akaike information criterion (AIC), Bayesian information criterion (BIC), adjusted BIC (aBIC), and a significant p value of bootstrapped likelihood ratio test (BLRT). However, the Lo-Mendell-Rubin likelihood ratio test (LMRT) value of the four-profile model was not significant (p = 0.76) and had the lowest entropy. Although a two-profile model produced decreased AIC, BIC, and aBIC values compared with the three-profile model and showed the highest value of entropy, the LMRT of the two-profile model yielded a p value > 0.05. Overall, the two- and four-profile models were unsuitable. The three-profile model was employed to best describe the various FT types among older cancer survivors in this study.

As shown in Figure 1, assignment of names to the latent profiles was based on a pattern of probability responses for items of each latent profile and a comparison of average values of variables for each latent profile. The majority of our sample (53.0%) belonged to a profile with the lowest scores on all items of inclusion. Overall, patients reported the lowest degree for Item 3, "I worry about the financial problems I will have in the future as a result of my illness or treatment" within the profile. We therefore designated this class the "high FT profile" (C_1). Several participants (35.5%) were characterized by moderate scores on each item. Overall, members of this profile had moderate perceptions, around the mean values for all 10 items while also displaying a similar tendency to the high FT profile (C_1). Item 3, "I worry about the financial problems I will have in the future as a result of my illness or treatment," and Item 4, "I feel I have no choice about the amount of money I spend on care," in the profile showed slightly lower degrees than other items. This profile was thus defined as the "moderate FT profile" (C_2). Although the third profile comprised only a small proportion of the sample (11.5%), it was a meaningful class with the highest scores on all items, indicating the lowest FT in the sample. Thus, it was correspondingly labeled the "low FT profile" (C_3). Item 10, "My cancer or treatment has reduced my satisfaction with my present financial situation," in this profile presented a reverse downward trend when compared with the item trends in C_1 and C_2. Each group of participants reported higher mean scores for Item 5, "I am frustrated that I cannot work or contribute as much as I usually do," and Item 7, "I am able to meet my monthly expenses." In addition, the mean scores of Item 6, "I am satisfied with my current financial situation," and Item 8, "I feel financially stressed," were relatively low at each class level.

Differences in financial toxicity among the three latent profiles

The differences in individual characteristics among the three latent profiles are presented in Table 3. Among the control variables, the clinical variables (including cancer site, cancer stage, length of cancer diagnosis, multimorbidity), sex, and marital status showed no significant differences across the three groups (p > 0.05 for all), whereas the subgroups differed significantly in the aspects of age, household monthly income, employment status, education level, insurance type, and living alone.

Table 1. Patient characteristics and COST values

Characteristic	N = 324	COST(Mean ± SD)[a]	Statistics	*P*
Age (range), y			4.543	< 0.001
60–64	86(26.5)	11.22 ± 8.95		
65–69	107(33.0)	11.68 ± 9.14		
70–74	81(25.0)	12.52 ± 10.35		
≥ 75	50(15.5)	16.80 ± 10.61		
Sex			1.209	0.231
Female	188(58.0)	13.02 ± 9.89		
Male	136(42.0)	11.70 ± 9.47		
Marital status			0.293	0.769
Married	302(93.2)	12.50 ± 9.91		
Other[b]	22(6.8)	13.14 ± 7.50		
Household monthly income (CNY)[c]			25.377	< 0.001
< 1,000	85(26.2)	9.68 ± 7.72		
1,000–2,999	66(21.3)	10.87 ± 9.04		
3,000–4,999	87(26.9)	9.77 ± 7.17		
≥ 5,000	83(25.6)	19.78 ± 10.96		
Employment status			16.003	< 0.001
Farming or part-time	74(22.8)	9.14 ± 7.47		
Unemployed	88(27.2)	9.25 ± 8.83		
Retired	162(50.0)	15.69 ± 10.01		
Education level			15.124	< 0.001
Primary school or below	148(45.7)	10.05 ± 8.48		
Middle school	72(22.2)	11.86 ± 8.28		
High school or above	104(32.1)	16.58 ± 11.09		
Insurance type			−6.19	< 0.001
URRBMI	187(57.7)	9.83 ± 8.48		
UEBMI	137(42.3)	16.26 ± 10.19		
Living alone			−3.399	< 0.001
Yes	80(24.7)	9.56 ± 8.76		
No	244(75.3)	13.52 ± 9.88		
Cancer site			1.651	0.161
Lung	160(49.4)	12.44 ± 9.95		
Upper gastrointestinal	57(17.6)	14.04 ± 9.51		
Colorectal	27(8.3)	12.15 ± 10.13		
Liver, gallbladder	29(9.0)	8.69 ± 7.82		
Other	51(15.7)	13.63 ± 9.94		
Cancer stage			1.815	0.144
0–I	8(2.5)	14.88 ± 8.84		
II	39(12.0)	9.26 ± 8.39		
III–IV	170(52.5)	13.05 ± 10.18		
Missing	103(33.0)	12.77 ± 9.49		
Length of cancer diagnosis (range)			0.762	0.446
≤ 1 year	206(63.6)	12.86 ± 9.71		
> 1 year	118(36.4)	12.00 ± 9.86		

(*Continued on next page*)

Table 1. *Continued*

Characteristic	N = 324	COST(Mean ± SD)[a]	Statistics	*P*
Multimorbidity			0.239	
0	161(49.7)	13.06 ± 9.92		0.788
1	93(28.7)	12.80 ± 9.69		
≥ 2	70(21.6)	12.18 ± 9.77		

Abbreviations: SD: Standard deviation; UEBMI = Urban Employees Basic Medical Insurance Scheme; URRBMI = Urban and Rural Residents Medical Insurance.
[a]Lower COST values indicate a higher FT.
[b]Other means single, divorced, or widowed.
[c]1,000 Chinese Yuan was equivalent to 150 US Dollars in 2021.

Risk factors for financial toxicity

Logistic regression was applied to examine potential risk factors (see Table 4) for high FT. We treated FT class as the dependent variable and the indicators with statistically significant differences in the aforementioned chi-square test analysis as the independent variables.

For the logistic regression, profiles were compared with each other (see Table 5). Participants aged 65–69 years (OR = 0.504, 95%CI: 0.176–0.797, p = 0.024), with household income monthly ≥ 5,000 CNY (OR = 0.405, 95%CI: 0.128–0.963, p = 0.016), and educated at high school or above (OR = 0.470, 95%CI: 0.104–0.543, p = 0.037) were more likely to be classified into the moderate FT profile (C_2) than in the high FT profile (C_1). Household income monthly ≥ 5,000 CNY (OR = 0.241, 95%CI: 0.055–0.471, p < 0.001) had a significant positive effect on the likelihood of being in the low FT profile (C_3) when compared with the high FT profile (C_1). Living alone (OR = 3.509, 95%CI: 1.091–9.290, p = 0.027) had a significant negative effect on the odds of being in the low FT profile (C_3) rather than the moderate FT profile (C_2).

DISCUSSION

This study classifies and characterizes the latent profiles of FT among older cancer survivors and innovatively investigates the predictors of FT across the identified classes. The individual responses to different items revealed that the heterogeneity of FT in older Chinese cancer survivors allowed three FT profiles to be distinguished (i.e., high, moderate, and low). Multinomial logistic regression analysis suggested that age, household monthly income, educational level, and living alone might be influencing factors in FT profiles. Compared with traditional classification approaches (e.g., K-means clustering), the LPA revealed fresh insights regarding the nature of inter-variation in FT of older cancer survivors.

Participants across the three profiles scored significantly differently on 10 FT items and reflected various levels of FT severity. The lowest scores on all items were observed in the high FT profile, which accounted for the largest proportion (53.0%) in the present work. In addition, 35.5% of the participants were classified into the moderate FT profile while only 11.5% were classified into the low FT profile, indicating the higher FT risk suffered by the patients in this study. Since a large number of participants in our study were included in the high profile, the FT severity illustrated in our study was a little higher than that indicated by previous studies. For example, in one study, only 5% of South Korean breast cancer survivors belonged to the severe FT group and 30% to the mild FT group.[32] According to a study in Japan, only 18% of participants were in the severe FT group, which was lower than the proportion of those in the moderate group (45%).[27] In a Chinese context, Jiang et al. found that the severe FT group accounted for a mere 2.4% of patients with nasopharyngeal carcinoma, while the mild and moderate FT groups accounted for 37.1% and 50.5%, respectively.[33] Focusing on older cancer survivors, the percentage in the high profile in our study is much higher than the figure observed in other studies. One study of 31 communities across the U.S. found that only 20% of older adults with advanced cancer experienced FT.[18] Another survey conducted in Mexico found that 0% of older patients with cancer reported severe FT, 52% reported mild FT, 39% reported moderate FT, and 9% reported no FT.[25] In the current study, the mean COST value among the study sample was 12.6 (SD: 9.8). Even though one item was deleted from the original measurement tool, the score was considerably lower than the scores among cancer survivors in the U.S. (Mean ± SD = 22.23 ± 11.89),[5] South Korea (Mean ± SD = 27.1 ± 7.5),[32] and Japan (Mean ± SD = 20.18 ± 8.17).[27] This difference may be explained by the fact that our study sample population was older and that nearly 52.5% of patients had stage III or IV cancer. Such individuals have been shown to undergo more additional medical treatment and higher expenditure than younger survivors or those with an early cancer stage.[34,35] In addition, most older adults have not participated in the formal

Table 2. Fit statistics for latent profiles: Model 1–4

Number of classes	*AIC*	*BIC*	*aBIC*	*P(LMRT)*	*P(BLRT)*	*Entropy*	Class probability
1-profile	5673.311	5741.238	5671.591	–	–	–	–
2-profile	5083.136	5188.114	5080.477	0.3401	< 0.001	0.939	0.80/0.20
3-profile	7992.005	8146.858	8013.663	0.0170	< 0.001	0.908	0.54/0.35/0.12
4-profile	4798.570	4977.650	4794.035	0.7607	< 0.001	0.889	0.31/0.40/0.20/0.09

Abbreviations: AIC, Akaike Information Criterion; BIC: Bayesian information criterion; aBIC, adjusted BIC; LMRT, Lo-Mendell-Rubin likelihood ratio test; BLRT, bootstrapped likelihood ratio test.

Figure 1. The three-profile pattern of COST items

labor force and, consequently, receive limited income and social welfare benefits. Therefore, it is particularly important to understand that FT is commonly prevalent in older Chinese cancer survivors and that it is imperative to develop policies and multidimensional interventions to effectively mitigate FT in this population.

Identification of protective factors for different classes is important for intervention planning. In this study, participants aged 65–69 years were more likely to be in the moderate FT profile than the high profile; that is, a relatively young age was associated with lower FT. However, data regarding the relationship between age and FT have been contradictory. Corrigan et al. reported that younger adults with cancer suffered disproportionate FT when compared to older adults,[23] while Chen et al. suggested that young and middle-aged patients with cancer had higher FT.[10] Moreover, using national data from multiple cities in China, Liu et al. reported that older age was significantly associated with lower FT among females with breast cancer.[36] However, Fu et al. reported findings consistent with the current results, showing that the adjusted OR of post-treatment impoverishment was higher for older patients than for younger ones.[37] Moreover, while comparisons in previous research were mostly conducted between younger and older adults, finding that younger individuals might experience more FT than older adults, the current study only concentrated on the inter-variation among the older cancer survivor population, observing that participants aged 65–69 years in particular were associated with lower FT among seniors aged 60 years and above. This indicates that classification is necessary and its application has value. Given the limited evidence for age differences in FT among older cancer survivors, more studies are needed to validate these results.

Socioeconomic status has been confirmed widely as a strong predictor of FT. Consistent with many previous studies,[6,7,32,38–40] the findings from this study suggested that cancer survivors from vulnerable income groups and with low education levels exhibited greater FT. This is not surprising because such individuals often have fewer financial reserves or support to draw on when financing medical or non-medical costs. Hence, they may have to sell assets, skip bill payments, borrow money, or incur bank debt, all of which could cause a higher FT level.[41] A comprehensive healthcare protection scheme for these vulnerable populations is necessary to cushion FT severity as early as possible.

We also found that living alone was an influencing factor for higher FT. This contention is widely supported by evidence from previous studies in China and other low- and middle-income countries.[24,42,43] Two possible reasons might explain this. First, households with only older adults may not have people to contribute income and, consequently, have limited financial resources. Previous research have confirmed that empty-nest households consisting of an older adult living alone had greater odds of incurring catastrophic health expenditure than those in which an older person lived with a spouse or in a multigenerational household.[44] Second, previous literature has highlighted that living alone may negatively impact self-care behaviors and adherence to a healthy lifestyle when compared with living with others.[45] Such differences may

Table 3. Individual characteristics and FT scores of the three profiles (N = 324)

Variable	Latent profile (N [%])			χ^2	*P*
	C_1 (High FT) (N = 173)	C_2 (Moderate FT) (N = 108)	C_3 (Low FT) (N = 43)		
Age (range), y				14.332	0.026
60–64	59(68.6)	19(22.1)	8(9.3)		
65–69	51(47.7)	41(38.3)	15(14.0)		
70–74	44(54.3)	26(32.1)	11(13.6)		
≥ 75	19(38.0)	22(44.0)	9(18.0)		
Sex				0.342	0.843
Female	98(52.1)	65(34.6)	25(13.3)		
Male	75(55.1)	43(31.6)	18(13.2)		
Marital status				0.945	0.374
Married	161(58.5)	87(31.6)	27(9.8)		
Other[a]	12(24.5)	21(42.9)	16(32.7)		
Household monthly income (CNY)[b]				30.544	< 0.001
< 1,000	49(57.6)	28(32.9)	8(9.4)		
1,000–2,999	35(50.7)	27(39.1)	7(10.1)		
3,000–4,999	61(70.1)	20(23.0)	6(6.9)		
≥ 5,000	28(29.8)	33(35.1)	33(35.1)		
Employment status				10.065	0.039
Farming or part-time	44(59.5)	24(32.4)	6(8.1)		
Unemployed	55(62.5)	25(28.4)	8(9.1)		
Retired	74(45.7)	59(36.4)	29(17.9)		
Education level				10.917	0.028
Primary school or below	86(58.1)	48(32.4)	14(9.5)		
Middle school	44(61.1)	19(26.4)	9(12.5)		
High school or above	43(41.3)	41(39.4)	20(19.2)		
Insurance type				10.048	0.007
URRBMI	113(60.4)	56(29.9)	18(9.6)		
UEBMI	60(43.8)	52(38.0)	25(18.2)		
Living alone				6.365	0.041
Yes	46(57.5)	30(37.5)	4(5.0)		
No	127(52.0)	78(32.0)	39(16.0)		
Cancer site				2.604	0.626
Respiratory	85(53.1)	52(32.5)	23(14.4)		
Digestive	65(57.5)	35(31.0)	13(11.5)		
Other	23(45.1)	21(41.2)	7(13.7)		
Cancer stage				0.157	0.997
I–II	26(55.3)	15(31.9)	6(12.8)		
III–IV	91(53.5)	57(33.5)	22(12.9)		
Missing	56(52.3)	36(33.6)	15(14.0)		
Length of cancer diagnosis (range)				3.727	0.155
≤ 1 year	106(51.5)	67(32.5)	33(16.0)		
> 1 year	67(56.8)	41(34.7)	10(8.5)		
Multimorbidity				1.833	0.766
0	37(52.9)	26(37.1)	7(10.0)		

(*Continued on next page*)

Table 3. *Continued*

Variable	Latent profile (N [%])			χ^2	*P*
	C_1 (High FT) (N = 173)	C_2 (Moderate FT) (N = 108)	C_3 (Low FT) (N = 43)		
1	47(50.5)	31(33.3)	15(16.1)		
≥ 2	89(55.3)	51(31.7)	21(13.0)		

Abbreviations: FT = Financial toxicity; UEBMI = Urban Employees Basic Medical Insurance Scheme; URRBMI = Urban and Rural Residents Medical Insurance.
[a]Other means single, divorced, or widowed.
[b]1,000 Chinese Yuan was equivalent to 150 US Dollars in 2021.

reflect the importance of support systems, especially support given by one's family or spouse.[16] The findings offer further evidence that older cancer survivors living alone should be considered a high-risk FT population.

Counterintuitively, this study found that there no any association between clinical characteristics and insurance types across the three profiles, somewhat contradicting several previous studies.[46] Moreover, a review by Lentz et al. revealed that patients with advanced cancers might have higher FT rates.[22] Furthermore, Yu et al. found that patients with URRBMI had, on average, 2.2-point lower COST score than patients who had UEBMI, since URRBMI had a lower reimbursement ratio than UEBMI.[47] Given the results from previous studies, our finding that there were no such differences across the three profiles must be interpreted with caution since the study sample was relatively limited, rendering the result prone to bias. Importantly, even though this study did not yield such significant correlations, healthcare policymakers should also give attention to these points.

Understanding distinct profiles and the influencing factor of different subgroups regarding FT issues among older patients with cancer could guide healthcare providers in the early assessment and identification of patients at greater risk. The current study contributes to the existing literature by providing a specific perspective, using LPA to advance our understanding of latent FT profiles among older cancer survivors and showing that being older, living alone, and having a lower education level and household income might be key predictors of higher FT scores. By distinguishing among different FT subgroups, healthcare providers and policymakers could better identify vulnerable individuals, which may help them to provide more personalized assistance. As a result, early tailored interventions could be designed to eliminate or reduce these risk factors. It will also be necessary to develop interventions that measure FT items experienced by older cancer survivors. For example, when resources are limited, maximizing the support for the physical and mental health of patients in the high FT profile and minimizing some unnecessary care of those in low or moderate profiles could lead to more accurate and effective interventions.

Conclusion

From a person-centered perspective, this study provides more insights into distinct FT profiles. Furthermore, it identifies risk factors for higher FT profiles. This study could help in the identification of high-risk patients and help healthcare providers to provide more person-centered care and assistance.

Limitations of the study

This study has several limitations. First, the data were collected in one economically and medically developed metropolitan city in the eastern coastal area of China. Whether the three FT profiles identified could be generalized to different regions remains unclear. Future research should broaden the sample regions. Second, it was only possible to assess FT profiles at one point in time since the study was cross-sectional

Table 4. The dummy variable assignment of multinomial logistic regression

Factor	Variable assignment instruction
Financial toxicity	High FT = 1; Moderate FT = 2; Low FT = 3
Age	60~64 = 1; 65–69 = 2; 70–74 = 3; ≥75 = 4
Household monthly income[a]	< 1,000 = 1; 1,000–2,999 = 2; 3,000–4,999 = 3; ≥ 5,000 = 4
Employment status	Farming, part-time = 1; Unemployed = 2; Retired = 3
Education level	Primary school or below = 1; Middle school = 2; High school or above = 3
Insurance type	URRBMI = 0; UEBMI = 1
Living alone	Yes = 0; No = 1

[a]1,000 Chinese Yuan was equivalent to 150 US Dollars in 2021.

Table 5. Risk factor for financial toxicity identified by multinomial logistic regression

	Variable	β	SE	OR 95%CI	Wald χ^2	P
C_2 vs. C_1	Aged 65~69	−0.587	0.385	0.504(0.176, 0.797)	6.753	0.024
	Household income monthly ≥ 5,000 CNY[a]	−0.840	0.532	0.405(0.128, 0.963)	5.655	0.016
	High school or above	−0.645	0.405	0.470(0.104, 0.543)	0.260	0.037
C_3 vs. C_1	Household income monthly ≥ 5,000 CNY[a]	−1.257	0.488	0.241(0.055,0.471)	10.761	< 0.001
C_2 vs. C_3	Living alone	1.256	0.586	3.509(1.091,9.290)	4.234	0.027

Abbreviations: OR: odds ratio; 95%CI: 95% confidence interval.
C_1: the high FT profile; C_2: the moderate FT profile; C_3: the low FT profile.
[a]1,000 Chinese Yuan was equivalent to 150 US Dollars in 2021.

and unable to extend the LPA to a latent transition analysis in profile membership between time points. Given that, after a diagnosis of cancer, FT changes across the whole disease treatment phase, and further longitudinal designs are suggested to explore the developmental trend and latent transition of patients' FT. Third, although several revisions were adopted with regard to the COST tool to render it more suitable for a Chinese setting, the tool emphasizes an individualized experience of FT and is limited to the psycho-social elements of FT. Consequently, the FT experiences of patients may be incorrectly estimated. Under the collectivist ethos of Chinese society, patients may have worries about the impact on their family well-being and financial future or may not even be willing to admit they are stressed financially. They may also decide to decrease their healthcare usage or avoid care. These concerns should be incorporated into future research. Fourth, we were not able to assess any relationship between ethnic minority status and FT severity since 99% of the populations of Shandong Province are members of the Han ethnicity. Ethnic minority status will be important when collecting more complete data with newer cohorts of cancer survivors in future research.

STAR★METHODS

Detailed methods are provided in the online version of this paper and include the following:

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SUPPLEMENTAL INFORMATION

Supplemental information can be found online at https://doi.org/10.1016/j.isci.2023.107768.

ACKNOWLEDGMENTS

General: We would like to express our gratitude to the following master's students at the School of Public Health, Shandong University, for their efforts during the field investigation period: Hanlin Yue, Jiajun Zhang, Lirong Yue, and Yulan Zhang.

Funding: Funding for this research was provided by the Shandong University Multidisciplinary Research and Innovation Team of Young Scholars (2020QNQT019), China.

AUTHOR CONTRIBUTIONS

Conceptualization, M.Z.S. and S.Q.L.; Methodology, M.Z.S. and L.L.; Software, L.L.; Formal Analysis, L.L.; Investigation, M.Z.S. and L.L.; Resources, M.Z.S.; Data Curation, J.H.L.; Writing-Original Draft, S.Q.L.; Writing-Review & Editing, M.Z.S., S.Q.L., L.L., F.W., and X.J.S.; Supervision, F.W. and X.J.S.; Funding Acquisition, X.J.S.

DECLARATION OF INTERESTS

There are no competing interests to declare.

INCLUSION AND DIVERSITY

We support inclusive, diverse, and equitable conduct of research.

Received: April 10, 2023
Revised: July 20, 2023
Accepted: August 25, 2023
Published: August 29, 2023

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STAR★METHODS

KEY RESOURCES TABLE

REAGENT or RESOURCE	SOURCE	IDENTIFIER
Software and algorithms		
Mplus 7.0	This study	http://www.statmodel.com/
SPSS 26.0	This study	https://www.ibm.com/cn-zh/spss

RESOURCE AVAILABILITY

Lead contact

Further information and requests for resources and reagents should be directed to and will be fulfilled by the lead contact, Xiaojie Sun (xiaojiesun@sdu.edu.cn).

Materials availability

This study did not generate new unique reagents.

Data and code availability

- All related information required to reanalyze or review the data reported in this paper is available from the lead contact upon request.
- This paper does not report original code.
- Any additional information required to reanalyze the data reported in this paper is available from the lead contact upon request.

EXPERIMENTAL MODEL AND STUDY PARTICIPANT DETAILS

Setting and sample

A cross-sectional exploratory study using LPA for the FT of older cancer survivors was performed, and the differences in FT between profiles were identified. Older cancer survivors were recruited from October 2021 to November 2021 in the oncology departments of Shandong Third Provincial Hospital and Jinan Center Hospital. Participants were eligible if they met the following criteria: (a) confirmed histopathological diagnosis of cancer; (b) 60 years of age or older when diagnosed with cancer; (c) at least one month since receiving their cancer treatment. This survey received ethical review approval from Shandong University (No. ECSHCMSDU20200901). The participants were informed of the purpose and duration of this study before the survey was conducted and could withdraw from the study at any time.

METHOD DETAILS

Data collection

We used convenience and cluster sampling in two general tertiary hospitals in Shandong Province, China, from October to November 2021. To improve the response rates, oncologists or nurses from hospital oncology departments helped identify potentially eligible participants among patients. After obtaining written consent from patients who were enrolled in the study, several nurses and public health postgraduates were hired to conduct the survey, and all received formal intensive training before the in-person interviews. The participants were informed of the purpose and duration of this study before the survey was conducted and could withdraw from the study at any time. The final number of participants in the recruitment was 330. The remaining 324 participants were retained in the current analysis, for a validity rate of 98.0%.

Measures

Individual characteristics of participants relating to demographic and clinical information were collected. Demographic characteristics included age, sex, marital status, household monthly income, employment status, education level, insurance type, and living alone. Clinical variables included cancer type, cancer stage, length of cancer diagnosis, and multimorbidity.

One of the most widely used instruments to measure FT is the COST patient-reported outcome measure developed by de Souza et al.[4,5] In a multi-step process, 155 patients with advanced cancer were interviewed to develop the 11-item COST tool. The 11 items were rated using a 5-point Likert scale with scores ranging from 0 (*very much*) to 4 (*not at all*). Final scores were summed for each of the 11 items and ranged from 0 to 44, with a lower score indicating a more severe FT.

In a Chinese setting, the periods of retirement, except for early retirement due to illness and injury, are typically 60–65 years old for males and 50–55 years old for females. Hence, the majority of subjects in the current study had retired or had no full-time job. Given this fact, we deleted Item 9, "I am concerned about keeping my job and income, including work at home," on the original scale because it had very little relevance in the setting. Thus, the C-COST contained 10 items, and the final scores ranged from 0 to 40. Items 1, 6, and 9 were reverse-scored. The C-COST questionnaire are shown in Table S1. The detailed process has been presented in a previous study.[48]

For determining reliability, internal consistency was evaluated using Cronbach's alpha coefficient. In addition, for a sample of patients with excellent adherence (N = 20), the C-COST measure was readministered within a 2-week interval (test-retest). A Cronbach's alpha $\geq$ 0.80 and ICC $\geq$ 0.75 were considered excellent.[49] The C-COST measure demonstrated excellent internal consistency with a Cronbach's α of 0.89, and the test-retest analysis revealed an ICC of 0.851 ($P < 0.05$).

Construct validity was assessed using explanatory factor analysis. The closer the Kaiser-Meyer-Olkin (KMO) value is to 1, the more common the factors among the variables, and the KMO value for factor analysis should be at least > 0.60.[50] The KMO value of C-COST was 0.815, and Bartlett's sphere test value was 593.62 ($P < 0.001$), which showed common factors among the overall correlation matrices and suitability for factor analysis. The 10 items of the C-COST were analyzed by principal component analysis, and two common factors were extracted, which accounted for 65.03% of the total variance. We used the orthogonal rotation method with maximum variance to analyze the factor load and took a load of a specific factor > 0.400 as the selection criterion for this factor. It was found that the load of 10 items on their main factors was more remarkable than 0.400, and thus no items needed to be deleted.

QUANTIFICATION AND STATISTICAL ANALYSIS

Descriptive statistics were employed to describe individual characteristics. Frequencies and percentages were adopted to describe participant characteristics. Means and standard deviations (SDs) were used to delineate COST scores. LPA was conducted to assign older cancer survivors to their most likely group based on their FT profile. We assumed that each older cancer survivor belonged to one of a set of *n* latent profiles, the number or size of which were unknown *a priori*. Several fit indicators were used to assess goodness-of-fit and to determine the optimal number of latent profiles. The best latent classes were finalized when the test values of AIC, BIC, and sample-size aBIC reached a relative minimum. To evaluate classification accuracy, relative entropy was measured, with values ranging from 0.0 to 1.0, with higher values indicating greater accuracy.[51] The LMRT and BLRT are tests of significance between two models with *k* classes and *k*-1 classes; a significant P value indicated that the *k* class was better.[52,53] Once the optimal number of latent profiles had been identified, the patients were classified into latent profile groups based on the most likely latent class membership. A chi-square test was used to examine patient characteristics and between-class differences in FT, and multinomial logistic regression analysis was used to identify influencing factors of class membership. LPA was estimated using Mplus 7.0, and other analyses were conducted using SPSS 26.0.