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The Financial Burden of Cancer: Financial Ratio Analysis

Radion Svynarenko[1,2] · **Qun Zhang**[1] · **Hyungsoo Kim**[1]

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Abstract
Using nine biannual waves (1998–2014) from the Health and Retirement Study, this study employed fixed-effects models to estimate the relationship between cancer and changes in financial status, measured by liquidity, solvency, and investment ratios. Results show that cancer survivors in the initial stage of cancer care increased their emergency fund equivalent to 15 days of living expenses, along with an increase in their debt to asset ratio by 0.8%, and a decrease of investment asset to net worth ratio by 0.4%. Furthermore, two additional years of post-cancer care and rehabilitation lead to an increase of five more days in emergency cash need and a decrease in investment asset to net worth ratio by 0.3%.

Keywords Cancer · Financial status · Liquidity · Solvency · Investment · Financial strain

Introduction

Older adults are the most vulnerable for being diagnosed with cancer. Over 86% of all cancer cases are diagnosed in adults aged 50 and older (American Cancer Society 2016), and 30–50% of those diagnosed may die from cancer within first 5 years of diagnosis (see Howlader et al. 2017). For older adults, cancer treatment is a life-long process, as it often becomes chronic and causes developments of numerous additional chronic conditions which require follow-up care. In fact, lifetime costs of cancer medical care together with initial diagnostic, treatment and post-cancer continuing care for a single patient often total over $100,000 (Stokes et al. 2011). And this is especially problematic for those who have no health insurance because they must pay the full price for their treatment. Unfortunately, with the partial repeal of Affordable Care Act, the number of uninsured Americans is expected to increase in the coming years (Congressional Budget Office Cost Estimate 2017).

Even cancer survivors with comprehensive employer-provided or Medicare health insurance policies face a serious financial burden (Arozullah et al. 2004; Shankaran et al. 2012; Smith et al. 2014). Some pay several thousand dollars in out-of-pocket (OOP) expenses before their insurance coverage starts up (American Cancer Society 2017; Stokes et al. 2011), while others reach their maximum annual OOP expenses in the first few months of treatment (Yabroff et al. 2009). High costs of cancer treatment together with the additional indirect burden coming from lost employment and financial stress for caregivers, results in a high "financial toxicity" of cancer treatment (de Souza and Conti 2017), which is a growing social concern.

To cope with the high costs of cancer treatment and post-cancer care, cancer survivors may make some financial adjustments. They may reduce their consumption and leisure activities, withdraw money from their retirement accounts, sell their stocks and investments, take medical loans, borrow money from family and friends, leave some medical bills unpaid, or increase their credit card debt (Jagsi et al. 2014; Shankaran et al. 2012). They may also use non-financial assets by selling or remortgaging their primary residential property, vehicles, or precious metals (Smith et al. 2014).

Cancer-related health care costs have been widely covered in existing literature (Arozullah et al. 2004). Yet, there appeared to be limited knowledge about the comprehensive impact of cancer on cancer survivors' financial status

✉ Qun Zhang
qun.zhang@uky.edu

Radion Svynarenko
rsv222@uky.edu

Hyungsoo Kim
hkim3@uky.edu

[1] Department of Family Sciences, University of Kentucky, 315 Funkhouser Bldg., 160 Funkhouser Dr., Lexington, KY 40506, USA

[2] Institute of Social and Political Psychology, Kiev, Ukraine

short-term after cancer diagnosis and long term in continuing care. Using the nine biannual waves of the 1998 through 2014 Health and Retirement Study (HRS) we examined the comprehensive impact of cancer on household finance by using financial ratio analysis. In particular, we answered the following three questions: (1) Did cancer survivors have enough liquid assets (cash) to cover medical expenses? (2) Were cancer survivors capable of paying off their liabilities? (3) To what extent did the burden of cancer affect their savings and investments for retirement?

Literature Review

From the treatment perspective, cancer treatment was categorized into three stages: initial, terminal, and continuing care (Brown et al. 2002; Yabroff et al. 2009). The initial and terminal stages of cancer treatment were considered the most expensive as the former stage commonly included expensive medical procedures such as radiation, chemotherapy and surgery, and the later stage included the intensive use of palliative care. In contrast, continuing care required only regular health check-ups and testing (American Cancer Society 2017).

Thus far, rough estimates of cancer treatment costs showed that the average cost of radiation in the US for cancer treatment varied by geography, type provided, and type of insurance (see Nelson 2015; Newhouse et al. 2013). One of the studies showed that the median cost of a radiation therapy course for breast, lung, and prostate cancer received by Medicare beneficiaries (Paravati et al. 2015) was $8600, $9000, and $18,000, respectively. The chemotherapy treatment of these three types of cancer was differential depending on the site and length of the treatment course (see Avalere 2012). Breast cancer chemotherapy received by a cancer survivor in a hospital outpatient department (HOP) on average costs $7529 per month; lung cancer—$12,312 per month; and prostate cancer—$9235 per month (Hayes et al. 2015). The average cost of breast cancer surgery was $12,987 (Barlow et al. 2001); prostate cancer surgery—$43,000 (Pate et al. 2014), and lung cancer surgery—$18,637 (Medbery et al. 2014). Continuing care for cancer survivors who required regular cancer screenings, blood tests, and help managing new chronic conditions developed during treatment, could cost as much as $10,000 per year (Hensley et al. 2005).

The cost of cancer treatment dramatically varied depending on type of health insurance. Cancer survivors who were beneficiaries of Medicare were financially worse off than those who had Medicare and Medigap coverage (Narang and Nicholas 2016). Private health insurance plans provided larger reimbursements than the government sponsored Medicare plan; however, they also required larger premiums (Fitch et al. 2016). For example, a case study from the American Cancer Society (2017) showed that the cost of cancer treatment for a breast cancer survivor totaled $144,193 in year 2016. Subtracting insurance payment of $140,218, the out-of-pocket expense was approximately $3975 for the year (Blumen et al. 2016; see Table 6 in Appendix for detailed insurance claim dollar amount). Health care sites funded by Veterans Health Administration (VA) provided care for a smaller cost than non-VA clinics, but they had lower rates of adoption of new treatment (Evidence-based Synthesis Program Center 2010; Walling et al. 2013). Non-insured patients experienced the most financial burden, as they paid full price for medical services and did not have the power to negotiate prices like private insurance companies or federal agencies. As a result, for the same kind of treatment, non-insured patients were billed from 2 to 43 times the amount as insured patients (Dusetzina et al. 2015).

Cancer was associated not only with high direct expenses, but also with additional financial burdens. For example, cancer survivors spent extra money on transportation, hotel stays, housekeeping, and eating out. These indirect expenses may have exceeded an additional $700 a month (Arozullah et al. 2004). As for the terminal stage of cancer treatment, the cost could top out at $5000. Cancer survivorship with post-cancer continuing care was also associated with large direct and indirect health care costs. Research showed a decrease in cancer survivors' employment by 7–14 h per week, resulting in a total of 16 or more workdays missed per year and a 24% drop in their income (Finkelstein et al. 2009; Short et al. 2008). For older cancer survivors, the financial burdens associated with the treatment and care could be more complicated when comorbidity occurred, which eventually lead to additional loss of productivity and a loss of 25–30% of the household's income (Dowling et al. 2013; Kahana et al. 2006; Malek and Silliman 2007).

To cope with these direct and indirect costs of cancer treatment, cancer survivors used a variety of financial resources. Many cancer survivors used their cash (29.9%), retirement savings (15.5%), or other investments (8.1%) to pay their medical bills. Some cancer survivors (16.7%) reported borrowing money from family and friends, and a very small number of them (5%) refinanced or sold their homes (Shankaran et al. 2012). These results paralleled studies showing that new adverse health events were associated with an increase of unsecured debt regardless of financial assets available to households (Babiarz et al. 2013) and could result in a medical debt of over $25,000 (Shankaran et al. 2012).

Overall, the review of literature revealed that cancer had substantial effects on households' financial resources. It was associated with an increase in immediate cash needs, an accumulation of medical debts, and the decline of household net worth and investment resources (Campbell and Ramsey 2009). To investigate these complex impacts, personal

finance scholars often used financial ratio analysis. Financial ratio analysis assessed the current financial situation of households, their strengths and weaknesses, and their progress in achieving financial goals (Garman and Forgue 2015). Since one ratio may not fully represent a household's financial status, financial advisors and educators recommended using several ratios (Greninger 1996). Among the commonly used ratios, liquidity (or liquid assets-to-monthly income ratio), solvency (debts-to-assets ratio), and investment (or investment assets-to-net-worth ratio) ratios provided the most comprehensive picture of the household's financial status (Baek and DeVaney 2004; Garman and Forgue 2015; Kim and Lyons 2008).

The liquidity ratio estimated whether a household had sufficient emergency resources to support the current level of expenses should there be a complete loss of income. It was an important measure, because cancer survivors may have to quit their jobs and lose earned income as a result of therapy and treatment. In other words, a liquidity ratio investigated how long a cancer survivor could afford their current consumption using only their current monetary assets such as cash or savings with no regular earned income. For example, a value of 3 showed that they could afford to cover their living expenses for 3 months. Although there were some discussions about the critical value of the liquidity ratio, numerous previous studies showed that a value below 2.5 indicated serious financial strain (Garman and Forgue 2015). Households with a very low liquidity ratio may not be able to survive financially during the early stage of cancer treatment and may not have enough time to find alternative sources of income (Baek and DeVaney 2004; Garman and Forgue 2015).

The solvency ratio showed the proportion of debts relative to total assets—whether a cancer survivor could afford to pay off all debts using his or her assets. The existing literature recommended that the value of debt should be less than half of the total assets (Winger and Frasca 2000). A person with debts equal to or more than assets was considered financially strained. This implied that even if they sold all their assets, they could not pay all their debts (Kim and Lyons 2008). Considering cancer survivors living with cancer may borrow money to pay for their medical bills (Gilligan 2013), this increased debt could lead to increased debts-to-assets ratio.

The investment ratio assessed the proportion of net worth kept in investment assets (Lytton et al. 1991). Investment assets were a fundamental part of retirement planning, serving as a salient financial resource in retirement (Yao et al. 2003). Several benchmarks of desired value of investment ratio were documented (Harness et al. 2008). While Lytton et al. (1991) suggested that at least 25% of net worth should be stored in the form of investments (Baek and DeVaney 2004; Kim and Lyons 2008), other scholars considered an investment ratio of at least 50% desirable (Greninger 1996). Compared with the ratio of 50%, Yao et al. (2003) indicated that 25% could reliably predict retirement adequacy.

There were several practical issues related to proper model specification that needed to be addressed when using financial ratios (Harness et al. 2008). For example, the problem with the liquidity ratio was that it was not always clear what drove the increase of the ratio: Some people increased their emergency funds by converting their wealth into liquid assets; others, experienced a drop in monthly income because of job loss. In both situations, the liquidity ratio increased. One solution for this problem was to include employment status in analytic models to control for financial effects associated with a change in employment. Another potential problem was collinearity between the numerator or the denominator of the ratio and control variables. One way to resolve this problem was careful testing for collinearity in models (see Horrigan 1965). The third problem with a ratio analysis was that ratios often had a non-Gaussian distribution which led to an increase of error rates. A traditional solution was applying different transformation strategies, such as logarithmic transformation or winsorizing (see Harness et al. 2008).

Studies estimating the proportion of OOP expenses in relationship to annual income (see Bennett and Dismuke 2010; Pumkam et al. 2013; Shankaran et al. 2012) seemed to overlook the effect of cancer on liquid assets, debts, and investments. Therefore, this study aimed to investigate the comprehensive financial impact of cancer on middle-aged and older Americans using financial ratio analysis, specifically: liquidity ratio, solvency ratio, and investment ratio. This analysis will provide answers to: (a) whether respondents with cancer had enough liquidity (cash equivalence) to pay for financial needs related to cancer treatment; (b) whether potentially increased debts from cancer treatment threatened the current financial security of cancer survivors; and finally, (c) whether having cancer affected savings and investment for financial needs in the future such as retirement.

Methods

Data

The RAND databases' Health and Retirement Study data were used for this study. The Health and Retirement Study (HRS) is one of the largest national representative studies that provides high-quality biannual data about the health and economic status of American adults over the age of 50 (Health and Retirement Study 2017). The RAND database provided data from all twelve waves of the HRS study from 1992 till 2014 (RAND 2016). In this study, we used waves

from 1998 to 2014. The first three waves from 1992 until 1998 were omitted due to between-wave inconsistency in the formulations of questions; inconsistency in imputation of missing values performed by RAND; and missing a cohort of respondents who were 62–67 years old at the time of the first wave in 1992, resulting in age non-representativeness for the first three waves (for details see Hauser and Willis 2004; Health and Retirement Study 1998).

From the RAND HRS database (RAND 2016) 37,495 respondents over nine waves from 1998 to 2014 were initially selected for the analysis. Inclusion criteria for this study required respondents to be 50 years or older resulting in the removal of data of 5317 respondents. The procedures resulted in a total sample of 32,178 unique respondents with 164,176 "person-wave" observations, an average of 5.1 observations per individual.

Measures of Financial Status

This study used two measures of financial status as dependent variables. One was financial ratios (liquidity ratio, solvency ratio, and investment ratio). The liquidity ratio was estimated by dividing liquid assets by monthly income. Liquid assets included the value of checking, savings and money market accounts, Certificates of Deposits (CDs), government savings bonds, and treasury bills. Monthly income was computed by dividing the sum of all annual income in a household by 12 months.

The solvency ratio was computed by dividing total debts by total assets. Total debts were computed by combining the value of all mortgages, all home loans other than the first or second mortgages plus the balance on any equity line of credit, and other debt. Total assets included: respondent's primary residence; net value of real estate; net value of vehicles; net value of businesses; net value of IRA/Keogh; net value of stocks and mutual funds; checking and savings accounts, and money market accounts; value of CDs, government savings bonds, and treasury bills; net value of bonds or bond funds; and net value of all other savings.

The investment assets ratio was calculated by dividing investment assets by net worth. The investment assets included the net value of stocks and mutual funds, the reported value of CDs, government savings bonds, and treasury bills, and the reported net value of bonds or bond funds. Net worth was identified as the net value of total wealth (excluding second home) minus all debt.

The other dependent was financial strain that indicated a financially stressful situation from levels of emergency fund, debt and investment for the future. Financial strain was represented by a set of binary variables: 1 if liquidity ratio < 2.5, solvency ratio > 1.0, or investment ratio < 0.25, respectively; 0 otherwise.

Around 6% of observations in the sample had either a zero value of income, assets, or net worth making it impossible to compute their financial ratios. Considering that zero values could be the result of the devastating impact of cancer treatment on survivors with low income, these observations were retained. Following recommendations of Kim and Wilmarth (2016), in these cases the solvency ratio was set to be equal to the numerator of the ratio, which is the amount of the total debt, indicating a lack of financial resources to meet debt obligations. The liquidity ratio was set to zero, reflecting inability to accumulate liquid assets to cover current expenses. The investment ratio was set to zero, showing a lack of financial resources that could be invested. The chosen approach to handling zero values in the denominators of the ratios indicated the poor financial status of these respondents. Additional sensitivity analysis showed that elimination of observations with zero value in the denominator of the ratios did not affect the robustness of the main effects in the models.

Outliers in the solvency, liquidity, and investment ratios were transformed using Winsor process (see Dixon 1960; Harness et al. 2008). This process replaces the extreme 0.5% of outliers with the next highest or lowest values in the sample transforming data to a normal and bell-shaped distribution. The main benefit of this method, in comparison to other techniques (e.g., log transformation), is that it retains all observations and allows data to be directly interpreted.

Independent Variables

Time-variant independent variables were measured biannually and included: cancer status, non-cancer severe chronic conditions, self-reported health, health behaviors, age, employment status, marital status, and type of health insurance. The cancer status was measured in two ways: whether it was the first bout of cancer (binary variable), and by the duration of cancer treatment (continuous variable). Following Narang and Nicholas (2016), chronic conditions were measured as a binary category—having one or more of the five most common non-accidental causes of mortality versus having cancer. The non-cancer chronic conditions included: (a) heart disease, heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems; (b) chronic lung disease, excluding chronic bronchitis or emphysema; (c) stroke or transient ischemic attack; (d) psychiatric problems, including emotional and nervous problems[1]; (e) type 1 and 2 diabetes, including high blood sugar.

[1] HRS measure of psychiatric problems is defined as general psychiatric conditions or problems, including Alzheimer's disease, a common cause of death of older people in western societies according to Center for Disease Control and Prevention (2016). Specifically, in waves 1998–2008, HRS measure of psychiatric problem included Alzheimer's disease. Starting 2010, HRS added a separate question of dementia along with the original question on general psychiatric con-

Self-reported health was measured as a binary category: fair to poor versus excellent to very good. Health behaviors were measured by binary categories—whether respondents ever drink alcoholic beverages or smoke. Demographic status was measured by variables with mutually exclusive subcategories: (a) employment status which was grouped into three subcategories, including employed (part or full time), retired, and unemployed; (b) marital status included married, separated/ divorced, widowed, and never married statuses; (c) age, which was grouped into three categories: 50–64, 65–74, and 75 years of age and older; (d) primary health insurances, which included: employer-provided, Medicare, Medicare with supplemental Medigap, Medicaid, and VA/ Champus. Total household income was measured in the 2014 US dollars and log transformed.

Time-invariant independent variables (gender, race and education) are presented in Table 1 for sample characteristics. The effects of these variables were considered as fixed and not estimated in fixed effects models.

Table 1 Sample characteristics

Characteristics	%
Cancer status	
Have cancer	14.0
Number of waves with cancer (mean)	3.3
Non-cancer severe chronic conditions[a]	50.0
Age (years)	
50–64	40.7
65–74	30.6
75 and older	28.7
Female	59.1
Non-White	24.5
Highest level of education	
Less than high-school	27.8
High school	30.5
Some college	21.7
College and above	19.9
Marital status	
Married/partnered	63.1
Separated/divorced/never married	15.9
Widowed	21.0
Retirement status	
Employed	27.4
Retired	59.6
Unemployed	13.1
Self-reported health	
Poor	30.3
Health behaviors	
Drinking	48.8
Smoking	13.9
Health insurance	
Employer provided	20.6
Medicare	33.4
Medicare + Medigap	22.9
Medicaid	9.1
VA/CHAMPUS	5.0
No insurance	14.1
Number of respondents	32,178
Number of observations (respondent × wave)	164,176
Mean observation per individual	5.1

[a]Non-cancer severe chronic conditions include heart disease, lung disease, stroke, psychiatric problems, and type 1 and 2 diabetes

Analytic Approach

Fixed-effects models were used to estimate the relationship between cancer status and changes in financial status. Fixed effects regressions were used for continuous dependent variables of financial ratios (Ashenfelter et al. 2002) while fixed effects logit regressions were used for binary dependent variables of financial strain measured by cut-off values of financial ratios (Wooldridge 2002).

The true advantage of the panel data in the HRS database is that by observing the same individuals over time it allowed the investigation of the effect of cancer treatment on the financial status of respondents. This analysis was done using a fixed-effects model (FE). FE models take the data from the same individual over time and subtract the mean value of all observations from each particular observation of the same person (Ashenfelter et al. 2002). In other words, the FE model looks at the relationships between deviation from the mean across observations and changes in the dependent variable. This, in turn, reveals dynamic relationships between predictors and dependent variables.

One of the key assumptions of FE models is that the effects of time invariant characteristics (e.g., gender or race) can be treated as fixed and not estimated in the model. The validity of this assumption can be tested using the Hausman test which tests the null hypothesis that these time invariant effects are not consistent across observations and need to be estimated in the model. The results of Hausman test in this study showed that the null hypothesis can be rejected (with $\chi^2 = 425.62$, and $p < .001$) and that FE is the appropriate model choice.

In addition, FE logit regressions were estimated with alternative benchmarks of financial strain for sensitivity checks. For a financial strain measured by the liquidity ratio, a new benchmark of less than 6.0 (see Garman and Forgue

Footnote 1 (continued)

dition. For consistency, this study used the question of general psychiatric condition across all waves to create the variable of psychiatric problems.

Table 2 Financial status (N = 164,176)

	Mean (SD)
Financial characteristics	
Liquid assets	21.35 (815.04)
Monthly income	4878.89 (16,657.62)
Total household income in 2014 dollars	69,336.41 (227,220.70)
Log of total household income in 2014 dollars	10.52 (1.46)
Debts	35,136.81 (86,718.36)
Assets	434,239.60 (1,078,682)
Investment assets	88,211.86 (460,235.70)
Net worth	399,102.70 (1,065,703)
Financial ratios	
Liquidity (liquid assets /monthly income)	7.91 (8.89)
Solvency (debts/assets)	0.17 (0.21)
Investment (investment assets/net worth)	0.09 (0.10)
Financial strain (thresholds of financial ratios)	%
Liquidity (< 2.5)	57.2
Solvency (> 1.0)	4.8
Investment (< 0.25)	84.0

2015, p. 78) was used instead of 2.5. For the solvency ratio, more than 0.5 (see Baek and DeVaney 2004) was used over 1.0. For the investment ratio, less than 0.5 (see Greninger 1996) was used rather than 0.25.

Results

An overview of the sample from the HRS waves 1998–2014 is presented in Table 1. Overall, 14% of respondents reported having a history of cancer during the period of the survey, for 5.1 waves on average, varying from 1 to 9 waves. Half of respondents had at least one of the five non-cancer severe chronic conditions. Among them 48.0% had chronic heart problems, 39.2% had type 1 or 2 diabetes, 30.8% had psychiatric problems, 18.4% had chronic lung disease, and 17.9% had suffered a stroke (additional descriptive statistics of chronic conditions is available on request).

Approximately 30.3% had poor self-reported health. Most had health insurance, 20.6% had it from private employers, 70.4% had it from the government such as Medicare, Medicaid, or VA/CHAMPUS for veterans, and 14.1% did not have any health insurance policies.

Table 2 shows cancer survivors' financial status using six financial characteristics (liquid assets, monthly income, total household income in 2014 dollars, debts, assets, investment assets, and net worth), three financial ratios (liquidity, solvency, and investment), and financial strain (measured by commonly used cutoff ratios in personal and household finance). In financial ratios, respondents had cash for emergency to finance 7.9 months of their current living expenses; their debts constituted around 17% of total assets, and they had 9% of investment assets out of their net worth. For financial strain, 57.2% of respondents were in a financially strained situation in the liquidity domain. Furthermore, the majority (84.0%) were at the risk of falling into financial strain in an investment aspect, but few respondents (4.8%) experienced financial strain from their debt level relative to their assets.

The impacts of cancer on financial ratios are depicted in Figs. 1 and 2 with 3,010 respondents who newly experienced cancer. Both figures show the ratios of pre- and post-cancer diagnosis. In particular, post-diagnosis ratios are demonstrated in two ways: the ratio in the first wave following cancer diagnosis, and the average of all waves

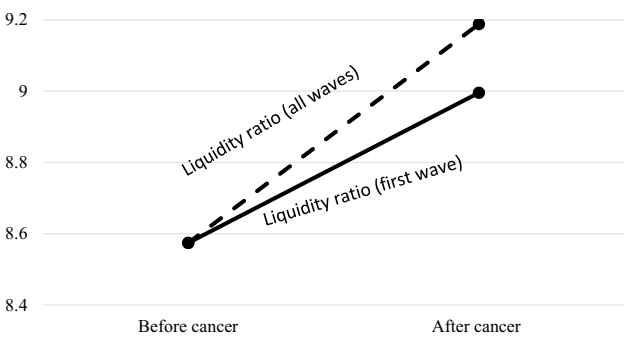

Fig. 1 Cancer and liquidity ratio: first wave after cancer diagnosis and average of all waves following cancer diagnosis ($n = 3010$ respondents with cancer)

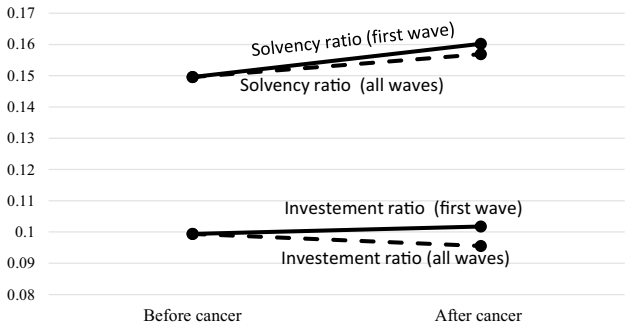

Fig. 2 Cancer and solvency and investment ratios: first wave after cancer diagnosis and average of all waves following cancer diagnosis ($n = 3010$ respondents with cancer)

since cancer diagnosis. Changes in liquidity ratio are shown in Fig. 1. During the first wave following cancer diagnosis, cancer survivors tended to have a higher cash holding rate by 4.6% [$(9-8.6)/8.6\times100$]; its average increased across nine waves was 6.9%. Figure 2 shows solvency and investment asset ratios pre- and post-cancer diagnosis. Respondents who experienced cancer had a higher debt rate by 6.7% and 4.7% for the first post-diagnosis wave and the nine-wave average, respectively. Interestingly, investment ratio increased by 3.0% during the first post-diagnosis wave, but it declined by 4.0% from a long-term perspective during continuous care, leading to lower investment asset out of net worth.

Table 3 presents the regression results of FE models to estimate cancer effect on respondents' financial ratios. Panel A shows the results using whether or not one had cancer as the dependent variable. Overall, the first self-report of cancer had statistically significant impacts on respondents' finance situation by increasing cash holding, causing more debt, and decreasing investment for the future. Having cancer was associated with a larger liquidity ratio (i.e., 0.501), indicating that when compared with those without cancer, cancer survivors had more cash for emergency equivalent to finance 15 days (0.501×30 days) of their current living expenses. Having cancer was also associated with a larger solvency ratio of 0.008, reflecting a 0.8% difference in the proportion of debts relative to their assets between respondents who had cancer and who did not have it. Furthermore, having cancer was associated with a lower investment ratio by 0.004, leading to 0.4% less in investment assets out of their net worth in comparison to those without cancer. Some other health characteristics controlled also had impacts on financial ratios. Having non-cancer chronic conditions decreased the investment ratio, but had no significant impacts on the liquidity and solvency ratios. Respondents with poor self-reported health (SRH) had lower liquidity and investment ratios but higher solvency than those with better SRH.

Several demographics had significant relationships with financial ratios. Not surprisingly, older age groups had a higher liquidity ratio and a lower investment ratio than younger counterparts (65 or younger). Retirees had a higher liquidity ratio than current workers, but a lower solvency ratio. Compared to married respondents, the divorced or the widowed had a higher liquidity ratio and a lower investment ratio whereas those never married had a lower solvency ratio. Health insurance coverage had impacts on liquidity and investment ratios, but not on solvency ratio. Respondents with Medicare and VA/CHAMPUS for veterans had higher liquidity ratios than those with employer-provided health insurance, whereas those with Medicaid had lower liquidity ratios. In addition, respondents with Medicare, Medicaid, and no health insurance had lower investment ratios. More income led to lower liquidity and debt ratios but also to a higher investment ratio.

Panel B shows the results when the dependent variable was the number of waves since the first self-report of cancer diagnosis to examine a lasting effect of cancer on financial standing. Similar to Panel A, the number of waves with cancer statistically increased cancer survivor respondents' cash holding for emergency and decreased investment for the future. The number of waves since the first cancer diagnosis was associated with larger liquidity ratio by 0.166, indicating that if cancer survivors had one additional wave to treat and manage cancer, they needed more cash equivalent to finance about 5 days (0.166×30 days) of their current living expenses. Furthermore, the number of waves since the first cancer diagnosis was associated with smaller investment ratio by 0.003, leading to a 0.3% less investment asset among their net worth by one additional wave to treat and manage cancer. However, unlike Panel A, the number of waves with cancer had no impact on solvency ratio.

The results of FE logit regressions are presented in Table 4, using financial strain as a measure of financial status. Recall that financial strain is defined as whether or not respondents had financial ratios below or above specific benchmarks (i.e., below 2.5 for liquidity, above 1.0 for solvency and below 0.25 for investment). Thus, if an odds ratio (OR) of having cancer is greater than 1 it is interpreted as increased odds of financial strain, whereas if the odds are less than 1 it decreases it. As seen in Table 4, the dependent variables in Panel A and Panel B were having cancer and the number of waves with cancer, respectively. In Panel A, the results showed that having cancer was associated with smaller odds of financial strain in the liquidity domain by about 13% (OR 0.882). There was no significant association between cancer status and the financial strain measured by solvency and investment ratios. As shown in Panel B, an additional wave to manage cancer was associated with larger odds of financial strain measured by investment rations by 3.3% (OR 1.033); however, there was no significant

Table 3 Fixed-effects regressions predicting financial ratios (N = 164,176)

	Financial ratios								
	Liquidity			Solvency			Investment		
	Coeff	SE	p	Coeff	SE	p	Coeff	SE	p
Panel A									
Health characteristics									
Have cancer	0.501	0.152	< .001	0.008	0.004	.027	− 0.004	0.002	.020
Non-cancer chronic conditions	− 0.090	0.108	.404	0.005	0.003	.072	− 0.007	0.001	< .001
Poor self-reported health	− 0.286	0.084	< .001	0.009	0.002	< .001	− 0.005	0.001	< .001
Drinking	0.206	0.092	.025	0.003	0.002	.234	0.004	0.001	< .001
Smoking	0.314	0.166	.058	0.000	0.004	.905	0.001	0.002	.547
Age									
65–74	0.397	0.128	.002	− 0.006	0.003	.058	− 0.009	0.001	< .001
75 +	1.120	0.163	< .001	− 0.003	0.004	.395	− 0.014	0.002	< .001
Employment status									
Retired	1.578	0.110	< .001	− 0.016	0.003	< .001	0.002	0.001	.215
Unemployed	1.499	0.135	< .001	− 0.008	0.003	.017	0.002	0.002	.223
Marital status									
Separated/divorced	0.685	0.205	.001	0.000	0.005	.987	− 0.001	0.002	.694
Widowed	1.444	0.132	< .001	− 0.005	0.003	.104	− 0.004	0.002	.013
Never married	0.646	0.493	.190	− 0.030	0.012	.009	− 0.008	0.006	.168
Health insurance									
Employer-provided	0.240	0.135	.075	− 0.007	0.003	.034	0.006	0.002	< .001
Medicare	0.566	0.153	< .001	− 0.002	0.004	.622	0.000	0.002	.841
Medicare + medigap	1.046	0.167	< .001	− 0.005	0.004	.236	0.006	0.002	.004
Medicaid	0.689	0.173	< .001	− 0.015	0.004	< .001	− 0.002	0.002	.292
VA/CHAMPUS	1.196	0.243	< .001	− 0.006	0.006	.264	0.002	0.003	.411
Log income in 2014 dollars	− 1.215	0.027	< .001	− 0.002	0.001	.003	0.005	0.000	< .001
Constant	18.034	0.329	< .001	0.200	0.008	< .001	0.044	0.004	< .001
Adjusted R^2		0.026			0.001			0.005	
Panel B[a]									
Number of waves after first cancer diagnosis	0.166	0.034	< .001	− 0.001	0.001	.400	− 0.003	0.001	< .001
Non-cancer chronic conditions	− 0.112	0.108	.303	0.005	0.003	.046	− 0.006	0.001	< .001
Constant	18.054	0.328	< .001	0.200	0.008	< .001	0.044	0.004	< .001
Other variables are controlled		Yes			Yes			Yes	
Adjusted R^2		0.027			0.001			0.006	

Control variables included: age 50–64, no cancer, no chronic conditions, good self-reported health, no drinking, no smoking, employed, married, no health insurance

[a]The other variables in Panel A are controlled

association between cancer status and financial strain when measured by liquidity and solvency ratios.

Sensitivity Analysis

Table 5 presents the results of sensitivity tests for financial strain with alternative thresholds: with the liquidity ratio < 6.0, the solvency ratio > 0.5, and the investment ratio < 0.5. Overall, results were similar to the main findings in Panel A and B in Table 4, both qualitatively and quantitatively, despite minor changes in statistical significances of liquidity and investment when using the number of waves with cancer. This implied that the benchmarked financial ratios used in this study were well reflective of a financial strain that indicated a financially stressful situation from levels of emergency fund, debt and investment for the future.

Table 4 Fixed-effects logit regressions predicting financial strain

	Measures of financial strain								
	Liquidity (< 2.5)			Solvency (> 1.0)			Investment (< 0.25)		
	OR	SE	p	OR	SE	p	OR	SE	p
Panel A									
Health characteristics									
Have cancer	0.882	0.038	.003	1.182	0.107	.066	1.030	0.057	.589
Non-cancer chronic conditions	1.078	0.033	.015	1.211	0.081	.004	1.045	0.042	.269
Poor self-reported health	1.076	0.027	.003	1.210	0.056	< .001	1.117	0.038	< .001
Drinking	0.880	0.023	< .001	0.997	0.052	.949	0.942	0.033	.089
Smoking	0.974	0.048	.600	1.015	0.079	.853	0.915	0.066	.214
Age									
65–74	0.860	0.032	< .001	1.040	0.071	.570	1.159	0.062	.005
75 +	0.878	0.041	.005	1.305	0.126	.006	1.101	0.071	.134
Employment status									
Retired	0.640	0.020	< .001	0.955	0.060	.464	0.876	0.038	.002
Unemployed	0.648	0.026	< .001	1.101	0.074	.152	0.918	0.052	.129
Marital status									
Separated/divorced	0.945	0.058	.358	1.522	0.138	< .001	0.883	0.079	.167
Widowed	0.869	0.032	< .001	1.307	0.107	.001	0.944	0.045	.223
Never married	0.973	0.159	.865	1.139	0.242	.541	1.446	0.377	.157
Health insurance									
Employer-provided	0.913	0.035	.017	0.845	0.062	.021	0.861	0.047	.006
Medicare	0.949	0.042	.237	0.940	0.071	.410	0.962	0.063	.557
Medicare + medigap	0.826	0.039	< .001	0.910	0.089	.335	0.839	0.057	.009
Medicaid	0.857	0.045	.003	0.892	0.071	.152	1.006	0.080	.942
VA/CHAMPUS	0.865	0.059	.032	0.923	0.129	.564	0.835	0.080	.060
Log income in 2014 dollars	1.144	0.009	< .001	0.969	0.011	.005	0.761	0.013	< .001
Pseudo R^2		0.014			0.007			0.009	
Panel B[a]									
Number of waves after first cancer diagnosis	0.993	0.009	.444	1.027	0.023	.245	1.033	0.012	.006
Non-cancer chronic conditions	1.074	0.033	.020	1.214	0.081	.004	1.035	0.042	.395
Other variables are controlled		Yes			Yes			Yes	
Pseudo R^2		0.014			0.007			0.009	
Sample size		91,569			23,339			55,222	

Control variables included: age 50–64, no cancer, no chronic conditions, good self-reported health, no drinking, no smoking, employed, married, no health insurance

[a]The other variables in Panel A are controlled

Table 5 Sensitivity test of financial strain with alterative thresholds

	Liquidity ratio			Solvency ratio			Investment ratio		
	< 6.0			> 0.5			< 0.5		
	OR	SE	p	OR	SE	p	OR	SE	p
Have cancer	0.822	0.037	< .001	1.069	0.069	.303	0.900	0.068	.167
Number of waves with cancer	0.970	0.009	.002	0.983	0.015	.261	1.012	0.016	.417
Sample size (observations)	83,647			44,114			32,291		

The other variables in Panel A in Table 4 are controlled

Discussion

This study showed the impact that cancer has on cancer survivors' financial status in the stages of initial and continuous care by using the 1998–2014 HRS data. To examine their comprehensive financial status after the diagnosis of cancer, we had focused on the cancer survivor's cash flow, debt, and investment assets to gauge their holistic financial wellbeing. Liquidity, solvency, and investment ratios were used as indicators of financial status to examine the above three financial aspects. In addition to these three ratios, we also use respondents' financial strain as a supplementary measure of financial status. This measure aimed to reveal whether cancer survivors fell into a financially strained situation defined by specific cutoffs of three financial ratios, which reflected: short on cash for now, debt burden, and low investment assets for future use.

Overall, the concordance of descriptive and regression analyses clearly showed that cancer survivors on both the initial stage of cancer treatment and on later stages of continuing care had more cash and less investment assets in comparison to those without cancer. This finding was robust after controlling for chronic health conditions, self-reported health, employment status, age, and the income level of cancer survivors.

Results indicated cancer care was associated with the increase of the liquidity ratio by 17 days on the initial stage of cancer treatment and by 5–6 days for every 2 years following diagnosis. A higher liquidity ratio could result from increased monetary assets, implying that cancer survivors were more prone to risk-aversive behavior additionally self-insuring themselves by keeping more cash available to cover any unexpected medical expenses (Briys and Schlesinger 1990; French and Jones 2011; Starr-McCluer 1996).

Results showed a pattern of decrease in investment assets by 0.4% on the initial stage of cancer treatment and by 0.3% every 2 years following the initial cancer diagnosis. Since investments mainly function as funds for future use, a smaller ratio suggested that retirement savings could possibly have been withdrawn earlier than necessary, implying that the savings intended for future financial stability had been reallocated to cover expenses associated with cancer treatment. Nevertheless, it is worth noting that despite a smaller investment ratio, cancer survivors did not fall into the category of an "investment ratio below 0.25," indicating that they were still able to maintain investments above the "safe line," keeping at least one quarter of their assets in the form of investment. In other words, if we use the benchmark of 0.25 for investment ratio, stocks or retirement funds may be cashed out temporally to buffer current cancer costs without overly exploiting money saved or invested, particularly for retirement. While the use of investment funds for cancer costs may help with financial resilience for now and reduce the survivor's dependence on borrowing, the tradeoff of exploiting investment assets may put cancer survivors at a disadvantaged financial position in the future.

The initial stage of cancer care was associated with increased debt-to-asset ratio by 0.8%, while continuing cancer care had no effect on this ratio. That is, cancer survivors in the initial stage of cancer treatment may temporarily use borrowing as a strategy to fund medical or nonmedical costs before financially adjusting or adapting to the increased health expenditure. This finding parallels the existing studies showing that the amount of debt increases after adverse health events (Babiarz et al. 2013). Meanwhile, a higher debt-to-asset ratio may also be attributed to shrinking assets, possibly because part of the total asset had been used to pay for the cancer-related costs, suggesting the wealth to be depleted by treatment or other non-medical expenses (e.g., transportation or special diet). Lack of statistically significant association between continuing cancer care and the debts-to-assets ratio may indicate that after initial treatment costs associated with cancer care may stop increasing as the health condition is kept under control. Meanwhile, in years after the initial cancer diagnosis, cancer survivors and families were given time to make adjustments on consumption and living, lowering expenses in non-cancer related categories. In addition, cancer survivors may also learn from experience on how to handle large medical expenses by utilizing their own financial resources, reducing the demand for borrowing.

Previous studies have indicated that individuals with chronic conditions and poor self-reported health experience a significant financial burden due to high OOPs (see Dowling et al. 2013; Narang and Nicholas 2016). The smaller liquidity ratio of those with poor self-reported health may indicate that they allocate more monetary assets (out of income) on long-term health maintenance such as prescription drugs or a specialized diet. A higher solvency ratio was found among respondents with poor self-reported health, which could result from a higher demand on borrowing to pay for extended medical expenditures, or less ability to repay existing debt due to limited employment opportunity. Lastly, a smaller investment ratio was associated with poor self-reported health, suggesting that the depletion of investment assets or retirement savings was a consequence of poor physical conditions.

The relationships between insurance coverage and financial wellbeing, overall parallels findings of previous studies (see Arozullah et al. 2004; Narang and Nicholas 2016). Overall, larger the liquidity and investment ratios of respondents with health insurances indicated that when compared with uninsured, they were all less at risk for future financial

instability. These findings were also supported by the examination of financial strains which show that compared with the uninsured, those who had employer-provided health insurance, or government health insurance experienced less immediate financial strains in the aspects of liquidity (< 2.5), and solvency (> 1.0). In the long-term, cancer treatment increased the risk of having inadequate investment assets.

Limitations

This study used a new approach of financial ratios to examine the comprehensive effects of cancer on cancer survivors' financial status, and found new and significant impacts on cash needs, debt and investment for the future. Further studies would need to refine cancer, measure and examine in depth the dynamics of cancer and financial ratios through cancer survivors' financial strategies to deal with treatment costs. Our cancer measures were (1) whether or not they had any cancer and (2) how long they had it, but we were not able to use the stages of cancer due to the unavailability of that data. The treatment approaches and costs differed over the stages of cancer, these things influence financial needs and status.

We could not also consider potential differences in financial burden across types of cancer at the time of diagnosis. This is an important implication of cancer on financial burden in that treatment costs substantially differ depending on types of cancer. In addition, despite our relatively comprehensive control of the health insurance effect in our estimation, we still could not consider the possible impact of cancer insurance. Some Americans purchase additional cancer insurances to reduce the financial burden of cancer (see Nielsen et al. 2001 for more information). These limitations stemmed mainly from the unavailability of related measures and restricted access to the HRS data that this study used.

We also need further studies to better understand the relationship between cancer and changes in financial ratios through the survivors' financial strategies to deal with cancer treatment cost. The current study focused on a direct relationship between cancer and change in financial ratios. We could not identify how cancer affects financial strategies (e.g., using own cash or borrowing), leading to change in financial ratios. Future studies may use research designed to investigate the direct and indirect impacts of cancer on financial ratios via the financial strategies commonly used by cancer survivors.

Implications

Findings of this study send important messages to scholars, educators, cancer survivors, and policy makers. In the research context, results indicate that OOP alone may not sufficiently capture the alteration of a cancer survivor's financial situation nor depict the person's financial adaptation to the disease. A full examination of the ability to sustain on-time payment (liquidity ratio), borrowing demand from cancer (solvency), and the utilization of retirement savings (investment ratio) is meaningful. In future studies, scholars are suggested to use similar ratios or develop comprehensive measures to build a reliable model on the financial impact of cancer.

Financial educators and policy makers should also be guided to consider the implications of the early exhaustion of retirement funds. Investment wealth depletion seems to be inevitable among many cancer survivors, implying the future financial stability may be dismal. Therefore, there is a need to raise public awareness of the long-term effects of cancer on investing for the future. It is important to consider additional social policies to potentially ease the financial burden of cancer.

These policies could be directed towards the extension of early cancer screening provided by Affordable Care Act. At the current time, only patients ensured by Medicare are eligible for early cancer screening (Soneji and Yang 2015). However, considering that many cancers develop before age of 65 (American Cancer Society 2016), it is reasonable to lower the age of government subsidized early cancer screening. This would enable early cancer diagnosis for those who cannot afford it, especially those without health insurances. It would also decrease the cost of continuing care as cancer treatment is more effective and successful in early stages than in the advanced stages (American Cancer Society 2017).

Another item that has serious impact on the financial security of cancer survivors is the high costs of treatment drugs (Howard et al. 2015). Cancer medication is often seen as overpriced and lacking governmental regulation (Beasley 2017). The cost of cancer medication continues to grow by about 10% annually (Gordon et al. 2018; Howard et al. 2015). As a result, cancer survivors, when faced with the high cost of cancer medication, chose to abandon their pharmacological treatment (Doshi et al. 2018). This problem, in part, had been addressed by the implementation of the government supported 340b drug discount program, which offers funding to hospitals that provide medical treatment to low income patients to buy drugs from pharmaceutical companies at a 25–50% discount (Fitch et al. 2016; Kantarjian and Chapman 2015). Although this made cancer treatment more affordable for low-income patients, it also resulted in an increase of the list price of drugs, adding additional financial burden to patents with heath insurances (Conti and Bach 2013). A solution to this problem could be developing new polices that would allow pharmaceutical companies to reduce the cost of developing new drugs and in stronger regulating of the pharmaceutical market (Howard et al. 2015).

The costs of cancer treatment may also be reduced by educating the patient about the available Community Oncology Clinics (COC). These community clinics provide services at smaller costs, they are also smaller than hospitals and are sometimes located closer to patients, especially to those living in rural areas (Roxanne 2016). This, in turn, significantly reduces the travel time and overall reduces the costs of cancer treatment (Hayes et al. 2015). However, the latest reports (see Community Oncology Alliance 2016) have indicated that these clinics experience financial hardship because of inadequate Medicare reimbursement and inadequate policies that prioritize higher cost settings (Roxanne 2016). New policies that would provide more funding for COCs could potentially significantly reduce the financial burden of cancer for patients.

Compliance with Ethical Standards

Conflict of interest Radion Svynarenko, Qun Zhang, and Hyungsoo Kim declare that they have no conflict of interest.

Research Involving Human and Animal Participants This article does not contain any studies with human participants performed by any of the authors.

Informed Consent Not applicable according to the ethical approval above.

Appendix

See Table 6.

Table 6 Average cancer treatment costs ($) allowed per patient by stage and type of treatment: breast cancer

Stage	12 months post-diagnosis			24 months post-diagnosis		
	Outpatient surgery	Radiation	Prescription drug	Outpatient surgery	Radiation	Prescription drug
I/II	11,783	14,910	2581	358	377	1440
III	12,637	21,133	3841	412	1100	1525
IV	4480	12,015	3316	557	3592	2355
Total cost[a]	85,772			103,735		

Cost allowed per patient comes from hospital claims data. It refers to the maximum reimbursement insurance will pay for the treatment costs per patient. Information is retrieved from original research by Blumen et al. (2016)

[a]Total cost includes surgery, radiation, medication, all inpatient services, oral chemotherapy, and miscellaneous specialized treatment

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Radion Svynarenko received his *Candidate of Sciences* in Psychology in V.N. Karazin Kharkiv National University, Ukraine. He is currently working on his doctoral degree in the Department of Family Sciences, University of Kentucky. He is interested in application of qualitative and quantitative methods in studying of intergenerational transmissions, financial support within families, retirement planning, health literacy, and health and aging.

Qun Zhang received her master's degree in Family Sciences at the University of Kentucky. Currently, she is working towards her doctoral degree in Family Sciences. Her interest is household debt and its impact on individual health and household wealth across life span. In her dissertation, she focuses on mortgage loans and adults aged 50+, exploring its relationship with retirement preparedness and health condition. Qun was awarded the award of Student of Distinction by the School of Human Environmental Sciences at UK in 2016.

Hyungsoo Kim Ph.D., an associate professor in the department of Family Sciences at the University of Kentucky, received his doctoral degree in Agricultural Economics at Kyoto University in Japan. His research centers on financial security and health among middle-aged and older Americans. His studies on non-cognitive motivational retirement savings using psychological self-regulation models and cognitive contributors of wealth accumulation such as financial literacy within limited financial resources have greatly contributed to the current field. His ongoing study of age at first job and wealth accumulation is likely to help young adults with career planning.