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Implications of Functional Limitations in Older Cancer Survivors A Medicare Beneficiary Survey

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IMPLICATIONS OF FUNCTIONAL LIMITATIONS IN OLDER CANCER SURVIVORS A MEDICARE BENEFICIARY SURVEY

by

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Dedication

This dissertation is dedicated to my parents and my sister, who have been a great source of support and encouragement to me throughout my time in graduate school. I am truly thankful for having you all in my life. Finally, I thank the Almighty for everything I have achieved so far in my life.

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Abstract

Prachi Chavan, MD, PhD, MPH. The University of Memphis. August 2019. Functional Limitations and their Implications in Cancer Survivors among Older Cancer Survivors. Major Advisor: Dr. Xinhua Yu, MD, PhD.

Purpose: The purpose of this dissertation is to evaluate the impact of physical and functional limitations among older cancer survivors and its effect on their healthcare utilization and mortality.

Method:

The Medicare Current Beneficiary Survey (MCBS) data from 2005 to 2013 are used in this study. MCBS is nationally representative longitudinal study of older Medicare beneficiaries. Physical Limitations (PL), Activities of Daily Living (ADL), and Instrumental Activities of Daily Living (IADL) are measured on a five-point scale. Propensity score weighting is developed using logistic regressions. Design-based descriptive analysis and logistic models with adjusted survey weights are performed. Logistic and Poisson regression models are developed for hospitalization, re-hospitalization and mortality rates.

Results:

Cancer survivors have higher functional limitations compared to non-cancer individuals. After adjusting for socio-demographic characteristics, cancer survivors are more likely to have physical limitations (OR, 1.62; 95% CI, 1.28-2.06). There is a one-year lag in functional limitations resulting in one-year loss of physical capabilities among cancer survivors compared to non-cancer beneficiaries. Older cancer survivors with physical and functional limitations have

a higher rate of emergency department visits than cancer survivors without limitations (PL: 21.8% vs. 8.7%, aOR, 1.72, 95% CI 1.26–2.35, p<0.05; ADL: 25.8% vs. 17.4%, aOR 2.68, 95% CI 1.86–3.86, *p*<0.001) and higher cost of hospitalization (IADL: mean = $24,916, SD ±3,877.1). Cancer survivors with poor self-assessed health had higher rate of hospitalizations (aOR, 1.60; 95% C.I, 1.47–1.72, p<0.0001) compared to non-cancer participants. Compared to participants with no history of cancer, cancer survivors with IADL (RR, 1.41; 95% CI 1.25–1.58, p<0.0001) and poor self-assessed health (RR, 1.39; 95% CI, 1.21-1.60, p<0.05) were more likely to have higher number of hospital readmissions within 30 days of a prior hospitalization.

Conclusion:

These findings extend our understanding of the burden of physical and functional limitations in cancer survivors. Older cancer survivors with physical and functional limitations have higher healthcare utilization compared to those without cancer. Addressing complex and unique healthcare needs in this population will help reduce excess burden on the healthcare system. Health care providers should incorporate formal assessments of functional status among older patients in their clinical practice.

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Chapter 1. INTRODUCTION

Cancer is rapidly changing from a life threatening condition into a chronic disease (Mols, Vingerhoets, Coebergh, & van de Poll-Franse, Lonneke V, 2005), and the life expectancy of people with cancer has improved over the years, owing to early detection of cancer, use of advanced technologies, newer treatments, and improved cancer follow up care (Gotay & Muraoka, 1998; Sweeney et al., 2006). The National Cancer Institute (NCI) and the American Cancer Society (ACS) define cancer survivors as any individual who has had a diagnosis of cancer; however, in epidemiological research cancer survivors are generally referred to as individuals who have survived the initial treatment, typically after one year of cancer diagnosis (Howlader et al., April 2015).

There are nearly 14.5 million cancer survivors living in the United States as of 2015, and the cancer survivor population may reach 19 million by the year 2024, with 9.3 million males and 9.6 million females (DeSantis, Siegel, & Jemal, 2015). Older cancer survivors account for almost two-thirds of cancer survivor population (DeSantis et al., 2015). Furthermore, six out of ten cancer patients are expected to live for five or more years due to new and improved treatment options along with good palliative care (Repetto, Comandini, & Mammoliti, 2001). Thus, about 60% of patients who have been diagnosed with cancer are now expected to live for five or more years (DeSantis et al., 2015).

Due to their weakened health cancer survivors often not only receive less optimal treatment options, such as incomplete doses, shorter treatment cycles, or being opted for conservative therapy instead of surgery, but they also suffer prolonged side effects of cancer treatment, which worsen their overall physical functioning and quality of life (Becker, Kang, &

Stuifbergen, 2012). Long term cancer survivors are more likely to have multiple co-existing medical conditions and experience more limitations in physical functioning compared to younger survivors (de Moor et al., 2013; Hardy, McGurl, Studenski, & Degenholtz, 2010). The effect of cancer and its treatment are of particular concern in the elderly because other age-related chronic condition such as hypertension and diabetes make them more susceptible to a decline in physical functioning (Guralnik et al., 1993).

Physical and functional limitations are key indicators of quality of life (Parker, Baile, Moor, & Cohen, 2003). Physical limitation refers to the limited physical strength to perform basic physical activities such as walking, lifting, stooping, sitting, and so on (Stineman, Margaret G. et al., 2014). Functional limitation refers to the inability of an individual to perform essential daily tasks for living a worthwhile life at home (Stewart, Ware Jr, & Brook, 1977). They are generally referred to as Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) (Katz, 1983; Lawton & Brody, 1970). ADL include personal activities such as using toilet, dressing, bathing, eating, and walking around the house; and IADL include social activities like shopping, managing bills and participating in events of social life (Field & Jette, 2007).The ability of performing these activities fulfills basic human needs and also measures an individual's quality of life (Sarvimäki & Stenbock-Hult, 2000).

Older cancer survivors have increased prevalence of functional limitations leading to the change in health-related quality of life when compared to those without cancer (Baker, Denniston, Haffer, & Liberatos, 2009). Many factors can increase the risk of functional limitations in long-term cancer survivor (Serraino, Fratino, Zagonel, & GIOGer Study Group, 2001). Functional limitations were found to vary by a patient's comorbidity status, socio-demographic characteristics and number of years post cancer diagnosis and treatment (Mols,

Thong, Vissers, Nijsten, & van de Poll-Franse, Lonneke V, 2012). Other studies identified demographic characteristics such as age, race, sex, socio-economic status, as well as self-rated health, and history of hospitalizations to be associated with functional decline and disability (Connolly, Garvey, & McKee, 2016; Germain, Vasquez, Batsis, & McQuoid, 2016). For example, decreased ADL is more prevalent among females, whereas decreased IADL is more prevalent among males (Serraino et al., 2001).

These adverse effects can be due to four reasons: first, cancer survivors often have multiple comorbidities or more chronic conditions such as hypertension, diabetes, osteoporosis when compared to those without history of cancer (Stuck et al., 1999). A systematic review by Stuck et.al. investigated risk factors for functional limitations in community-dwelling older people identified upper and lower extremity dysfunction, cognitive decline, chronic conditions, high and low body mass index (BMI), medications as risk factors for functional limitations (Stuck et al., 1999). A recent study by Germain et.al, demonstrated that older individuals with higher muscle strength have lower odds of having functional limitations when compared to those with poor muscle strength (Germain et al., 2016). Wahlgren et.al used Charlson's comorbidity index to demonstrate that comorbidities have an impact on the global health and physical functional domain of health- related quality of life among prostate cancer survivors. However, addressing comorbidity is a complex issue in older cancer survivors, as it interferes with cancer treatment and follow-up care (Wahlgren, Levitt, Kowalski, Nilsson, & Brandberg, 2011).

Second, cancer survivors are more likely to visit a primary care physician (Yu, McBean, & Virnig, 2007); frequent clinical encounters may increase the likelihood of detecting functional limitations. Third, cancer survivors have increased prevalence of psychosocial factors such as poor mental health, depression, and elevated stress levels which are potential risk factors for

functional limitations (Keating, Nørredam, Landrum, Huskamp, & Meara, 2005). Fourth, cancer survivors are less likely to engage in preventive health behavior such as exercise and maintaining a healthy diet and are more likely to engage in risky behaviors such as smoking compared to non-cancer survivors which might increase the prevalence of functional limitations in them (Stuck et al., 1999).

These factors could be vital in determining the impact of functional limitations among older cancer survivors and how it may have an indirect effect on the healthcare use in this population. The long-term medical expenditure for a disabled older person is almost 3 times more than that of a nondisabled senior (Freedman, Martin, & Schoeni, 2002). According to the American Community Survey, the overall rate of disability in the United States was 12.6% in 2014 (Kraus, 2015). Prior studies have also shown that both functional limitations and comorbidity are strong indicators of healthcare use among cancer survivors (Repetto et al., 2001; Song, Ji, & Nielsen, 2014; Thong et al., 2011). Comorbidities such as obesity can have an added impact on functional limitations which may invariably increase the health care cost in older adults (Ahn, Huber Jr, Smith, Ory, & Phillips, 2011).

Self-assessed health was also found to be an independent predictor of functional decline in older adults (Lee, Y., 2000). In the past decade, increasing evidence has emerged about people's self-rated health and their length of survival. After considering a variety of clinically prognostic factors, a strong predictive relationship was found among self-assessed health and length of survival (Shadbolt, Barresi, & Craft, 2002). Considering the predictive value of self-assessed health in community population, it may act as a valuable tool for assessing the health of cancer survivors living in the community. There is a paucity of studies examining the impact of functional limitations on self-assessed health status, the prediction of mortality in older cancer

survivors and its implications on the healthcare system (Chatterji, Byles, Cutler, Seeman, & Verdes, 2015). There may be other modifiable lifestyle factors which might alter this relationship but studying the association of these factors with indicators of disability will help us understand the value of self-assessed health in predicting functional ability and risk of mortality among the older cancer survivors. Although previous studies have focused on self-rated health in older adults (Matson et al., 2019; Meltzer et al., 2017), no study has examined self-assessed health as a tool for predicting functional ability and how both predict the risk of mortality in older cancer survivors.

Research Gap

Physical limitations, functional limitations (ADL & IADL), and self-reported health status are important indicators of health and healthcare use among cancer survivors (Spector & Fleishman, 1998). They are also a good predictor of self-perceived disability and risk of mortality in older cancer survivors; (Becker, Kang, & Stuifbergen, 2012; Deimling, Sterns, Bowman, & Kahana, 2005; Trentham-Dietz et al., 2003). However, little is known about the health and disability status of cancer survivors. Hence a comprehensive understanding of factors which influence ADL and IADL among older cancer survivors will contribute towards future planning of healthcare services for them (Katz, 1983; Lawton & Brody, 1970). Functional limitations can significantly restrict participation of older cancer survivors in activities of social life, increase anxiety, social isolation and depression in them (Parker et al., 2003). These activity limitations reflect the degree of functional independence at home which in turn affects the use of medical care and healthcare outcomes. Furthermore, much attention has recently been directed towards long term cancer survivors to manage and identify treatment related problems in them, and to improve quality of life and enhance the overall functionality of those individuals

(DeSantis et al., 2015). ADL and IADL measure functional decline among older people which affect their ability in the long run to function independently at home (Wolinsky et al., 2011). However, not many studies have assessed the burden of physical and functional limitations among older cancer survivors and its impact on ability of these survivors to function independently using the causal inference theory.

In addition, cancer survivors with functional limitations may have increased healthcare utilization owing to their chronic illness and other comorbidities. Prior research has focused on direct healthcare costs related to cancer diagnosis in terms of hospitalizations, physician visits, and outpatient care (Brown, ML & Yabroff, 2006; Brown, M. L., Riley, Schussler, & Etzioni, 2002; Riley, Potosky, Lubitz, & Kessler, 1995). However, there may be other healthcare related cost of cancer diagnosis and treatment. Not many studies have focused on the health care utilization and cost incurred by long term cancer survivors. Only a few population-based estimates of health care utilization in cancer survivors are available in the United States. In this study, we will be using data from a large nationally representative sample of cancer survivors to estimate their healthcare utilization in terms of recurrent hospitalization, rate of emergency department visits, number of outpatient care and so on. The results will help in tailoring plans for cancer survivors that are responsive to their healthcare needs after cancer diagnosis and treatment.

Mechanisms and Theory

Physical and functional limitations, or disability in general, are some of the inevitable consequences of aging. As age increases, the normal physiological mechanisms of the body decline gradually and the ability of the body to combat diseases decreases as well (Pope &

Tarlov, 1991). For example, the immune response slows down, and immunological strength decreases with age, which prolongs the duration of illness and hinders normal recovery (Nagi, 1976). Furthermore, pathological conditions such as atherosclerosis, osteoporosis, diabetes, and hypertension also emerge (Field & Jette, 2007). These conditions can affect physical and functional abilities throughout a person's life.

The understanding of disability and functional limitations has changed in the past few decades (Field & Jette, 2007). A common conceptual framework of the disability process includes pathophysiological changes in the body and impairment in bodily functions, which lead to functional limitations in ADL, and eventually causes disability in a person (Nagi, 1976). This following concept was first introduced by the Institute of Medicine (IOM) in year 1991 and has been revised over the period of years (Pope & Tarlov, 1991).

Figure 1: IOM framework of disability process

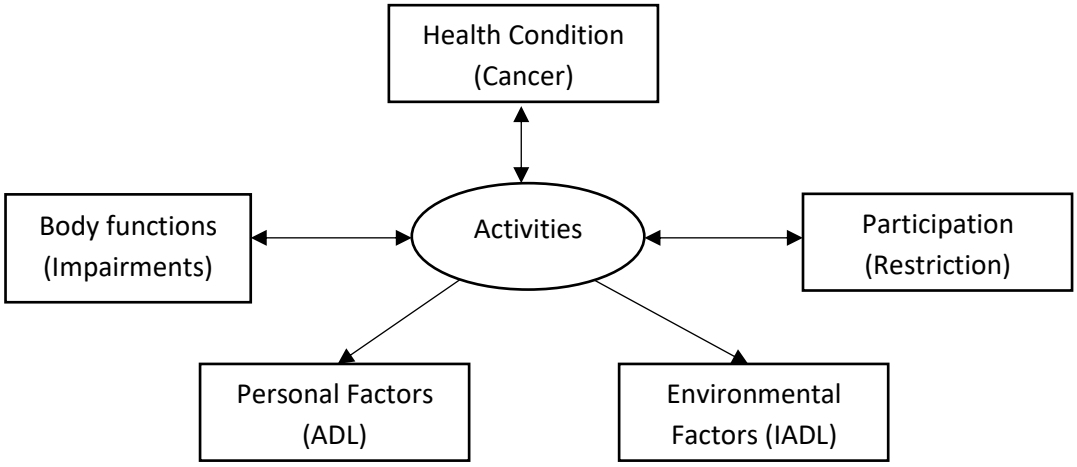
The World Health Organization has also developed a new *International Classification of Functioning Disability and Health* (ICF) (World Health Organization, 2013). The ICF framework is based mainly on a comprehensive view of health status and it is described by the ICF as the product of the interaction between various health, environmental, and intra-personal factors (Field & Jette, 2007). The ICF defines disability as an umbrella term for functional limitations, impairment, and restricted participation in activities (Mitchell & Snyder, 2006). The conceptual framework of ICF starts with a health condition, which could be a disease, a disorder, a trauma, or an anomaly. The ICF framework also includes aging as a health condition, which

increases the possibility of developing impairment in the body, limiting daily activities, and restricting participation in social life (Field & Jette, 2007).

In addition, as stated by Snyder, "disability is not an individual attribute but an interaction between the individual and the environment (Mitchell & Snyder, 2006). Evaluating disability or physical and functional limitations should consider both physical environment and societal factors along with the aging process. Any interruption caused in the normal functioning of the body due to external environmental factors, such as trauma, stress, or a disease condition brings about pathophysiological changes in the body (Field & Jette, 2007). These changes are commonly seen with increasing age, and the increasing presence of comorbidities with age may exacerbate physical and functional limitations in older adults. For example, with age, the immunity of the body decreases, and the number of medical conditions increase disrupting the normal functioning of the body (Nagi, 1976). This disruption not only leads to physical and anatomical impairments in the body but also causes mental and emotional changes. All these impairments may result in restriction in the ability to perform an activity of daily living in a normal manner. Over time, functional limitations in activities of daily living create a gap between the person's capacity to get things done and physical demands which are socially relevant. This inability to perform socially defined roles and activities within the daily environment leads to disability in both physical and mental domains of health. Thus, the concept of functional limitation distinguishes between basic activities of daily living, which are necessary to function independently in the house and in the community (Grov, Fosså, & Dahl, 2010), which are further categorized as activities of daily living (ADL) and Instrumental Activities of Daily Living (IADL) (Stineman, Margaret G. et al., 2014).

Recognizing the need to address the disability issue among older adult population in the US, the IOM created a comprehensive disability monitoring system, namely the International Classification of Functioning, Disability and Health (ICF) (Pope & Tarlov, 1991).

Figure 2: IOM's disability monitoring system



In this system, activity was defined as "the execution of a task" whereas participation was referred to as "involvement in life situations." Consequently, the ICF established a disability staging system to describe the patterns of activity limitations across ADLs and IADLs. Each included six tasks, corresponding to ICF chapters on domestic life and self-care. The ADLs were described as everyday personal tasks of self-care, whereas the IADL were described as more complex domestic tasks of daily life including management of household and other activities necessary for all individuals to participate in social life. The ICF also designed five stages of ADL and IADL to reflect standard performance (Pope & Tarlov, 1991). Stage 0 represents "no limitations", stage I "mild", stage II "moderate", stage III "severe" and stage IV "complex". People at stage I and II can perform all activities except for a few and people at stage IV experience difficulties in performing most tasks of daily living. Higher ICF stages are associated

with more comorbidities, history of multiple falls, difficulties inside the home and history of multiple hospitalizations in previous months (Schüssler-Fiorenza Rose et al., 2016; Stineman, Margaret G. et al., 2014).

In addition, difficulty in physical function of daily life was aggregated into four groups by Fried et.al (1994). The first group included activities primarily dependent on exercise and mobility; the second group included complex activities heavily dependent on cognition; the third group included basic self-care activities of daily living, and the fourth group included upper extremity activities. Activities in the second and third groups are similar to ADL and IADL, but each activity is associated with a different underlying impairment. For example, ability to move from bed to chair may be compromised by a different underlying impairment than the ability to eat, although both are ADLs (Fried, L. P. et al., 1994).

Aging brings about more health problems and a decrease in functional capacity, and the decreased functional capacity, in turn, leads to poorer health and additional healthcare cost (Freedman et al., 2002; Fuller-Thomson, Yu, Nuru-Jeter, Guralnik, & Minkler, 2009). This vicious cycle also affects the quality of life indirectly (Stuck et al., 1999). The development of functional limitations in older population is often complicated, multifactorial, and a result of interaction between physical, personal and social environment of the individual (Duba, Rajkumar, Prince, & Jacob, 2012). The increasing prevalence of disability globally has led to an increased interest in predictors of disability and functional limitations among older adults. In recent decades, more attention has been given to the quality of life of older individuals especially those with life threatening diagnosis, such as cancer.

On the other hand, patient satisfaction was found to be another determinant of health status in these individuals (Bogner et al., 2015). A healthy and satisfied life encompasses perceived health, functional capacity, and good social relationships (Sarvimäki & Stenbock-Hult, 2000). In a few prior studies, satisfaction was related to disability, whereas other studies have shown that a greater number of limitations in ADL led to greater patient dissatisfaction (Jha, Patrick, MacLehose, Doctor, & Chan, 2002). Determinants of health and healthcare use are heterogeneous and vary according to different strata of life. With the rapidly increasing older population, it is highly likely that older adult population will have difficulty in ADLs and IADLs; therefore, maintaining independence in activities of daily living is a very important issue for older people (Connolly et al., 2016).

Functional limitations among cancer survivors

Older cancer survivors also suffer from prolonged consequences of cancer and its treatments. The diagnosis of cancer has been found to be associated with pathophysiological changes, fear of death, changes in quality of life and an overall sense of loss of control (Parker et al., 2003). The side effects of surgery, chemotherapy, and radiation therapy may impair certain functions of the body (DeSantis et al., 2015). Also, older cancer survivors often receive fewer optimal cancer treatment options due to their frail conditions which may further deteriorate their overall well-being. They are more likely to have multiple chronic conditions, thus experiencing additional physical and functional limitations compared to individuals without a history of cancer (de Moor et al., 2013; Hardy et al., 2010). Thus, the diagnosis and treatment of cancer along with the presence of comorbidities lead to weakness which impairs the normal functioning of the body. The term impairment indicates abnormality or loss of an anatomical, physiological, psychological or emotional nature (Field & Jette, 2007). Functional limitations are a

manifestation of impairments in the whole body, which may further lead to disability in an individual.

The long-term impact of chemotherapy on the quality of life of cancer survivors deserves a special attention. Taylor et.al. demonstrated that patients who underwent chemotherapy were three times more likely to be disabled compared to patients who did not undergo chemotherapy. Although chemotherapy appears to be associated with disability, it seems that the decision regarding modes of treatment are more concerned with outcomes such as survival and recurrence rate, and are only secondarily influenced by concerns of disability and quality of life (Taylor & Currow, 2003). Hence, there is a need to identify the long-term effects of cancer diagnosis and treatment which may contribute to the burden of functional limitations in long-term cancer survivors (Yang et al., 2012).

Functional limitations add a burden of ailments to the lives of older cancer survivors, affecting their long-term ability to function independently. While advances in detection of cancer and its treatment have reduced mortality, disability is now considered to be as important as mortality. A detailed study by Fried et.al demonstrated that comorbidity, disability and frailty in older individuals can be present independently or they may be dependent on each other (Fried, L. P. et al., 1994). A large multicenter study conducted in Italy by Serraino et.al concluded that majority of older cancer patients had ADL and IADL disability and comprehensive geriatric assessment scale was a useful tool to measure functional limitations among older cancer population (Serraino et al., 2001). A study by Grov et.al suggested that older cancer survivors had higher ADL when compared to cancer free controls and further suggested that comorbidities increased the prevalence of ADL and IADL problems in them (Baker et al., 2009; Grov et al., 2010). A study by Jones et.al suggested that cancer related fatigue is present among one-third of

cancer survivors for up to 6 years post diagnosis and treatment and is associated with high levels of functional disability. The main factors associated with cancer related fatigue were found to be depression, comorbidity and burden of illness (Jones, M.J.; Oslon, K.; Catton, P.; Catton, CN.; Fleshner, NE.; Krzyzanowska, 2016).

Assessment of functional limitations can potentially identify the changing sequelae among cancer survivors, which could be useful in making treatment decisions and improving health outcomes (Baker et al., 2009). In 2003 a study by Parker et.al found that factors such as psychosocial support, current health condition, recurrence of disease and type of treatment received were some of the predictors of quality of life in cancer survivors (Parker et al., 2003). They also suggested that women reported more distress and poorer adjustment in various domains of life when compared to men and socio-demographic characteristics were important predictors of the overall health status of cancer survivors.

Given the complexity of care for older cancer survivors, the use of health care services is becoming more cumbersome (Yu et al., 2007). Older cancer survivors not only visit their primary care physicians but also have multiple visits to oncologists, cardiologists and other specialists to address their additional health concerns. Coordinated care among primary care physicians, geriatricians, oncologists, and other specialists is the key to improve the health of this population. The inclusion of multi-disciplinary care for these survivors may be helpful in reducing the burden on the healthcare system.

A report on U.S. Preventive Services Task Force, by Williams and Wilkins in 1996 demonstrated that for physicians to implement all recommendations of preventive care, they need to spend at least 7.5 hours a day with the average number of patients they see each day (US

Preventive Services Task Force, 1996). On the other hand, Stange et.al concluded that physicians can devote only one minute to preventive care of the total 13 minutes used to see each patient on the average (Stange, Woolf, & Gjeltema, 2002). The primary care physicians have multiple roles to play in any given patient visit. They may need to address chronic problems, acute symptoms, psychological problems, counsel for behavioral change, preventive services and also administer other aspects of care giving (Glasgow, Bull, Piette, & Steiner, 2004). The "competing demands" model developed by Jaen et.al considers these issues and describes the three main domains which influence the outcome of each medical encounter with the primary care physician (Jaen, Stange, & Nutting, 1994).

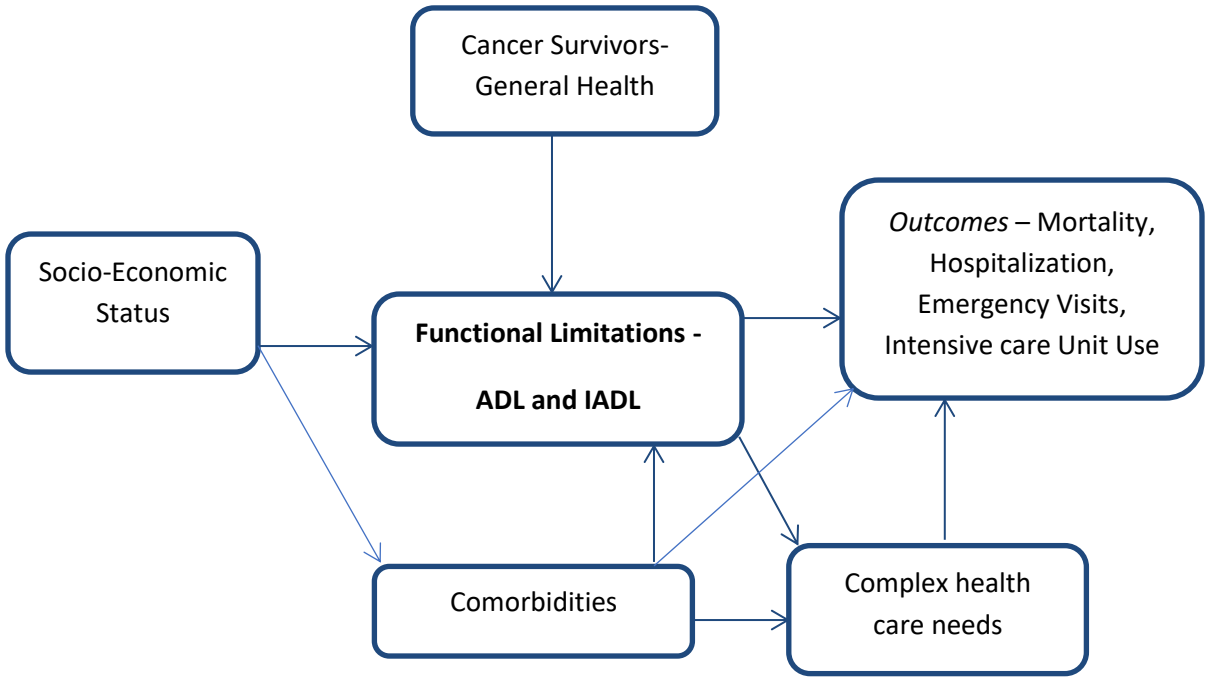
Older cancer survivors are also more likely to use supportive medical services, thus, have higher healthcare utilization than those without cancer. The national estimates of healthcare expenditure show that older cancer survivors have higher utilization rates of healthcare services, compared to other chronically ill patients (Bernard, Farr, & Fang, 2011). Older cancer survivors not only have higher overall healthcare expenditure, but also have excess healthcare expenditure, which continued even after many years of cancer diagnosis, compared to individuals without a history of cancer (Guy Jr et al., 2013). Understanding the intricate relationship between self-assessed health, physical limitations and functional limitations, and its impact on health care utilization allows the health care providers to make well-informed decisions and optimally deliver health care to older cancer survivors.

Functional limitations represent an early and key transition in the path to disability and should be taken as a sign to implement interventions which reduces the risk of disability, morbidity and mortality among cancer survivors (Schootman, Aft, & Jeffe, 2009). Socio-demographic characteristics, patients' general health status, comorbidities, use of healthcare

services and so on. These factors may interact with each other, for example, increased comorbidities may lead to complex health care needs and the number of comorbidities in a person may differ based on their socio-economic system. Similarly, complex healthcare needs may arise from the presence of functional limitations which leads to an increase in healthcare utilization. All these factors together may have an impact on functional limitations in cancer survivors.

The following diagram depicts a conceptual framework for implications of functional limitations in cancer survivors:

Figure 3: Conceptual Framework (Implications of functional limitations in cancer survivors)



The growing concern and associated threats to functional ability of cancer survivors have encouraged investigators to explore the implication of functional limitations among cancer survivors. There is a need to further examine the implications of physical and functional limitations among older cancer survivors. Along with prolonging life of cancer survivors, the goal is to also preserve functional capacity in them, including increased independence, reduced hospitalization, alleviating pain, and improved functional ability.

Study plan

In this study, the aim is to examine the determinants of functional limitations and their impact on the health care utilizations among elderly cancer survivors. Specifically, the aim is to:

SA1: Assess the burden of functional limitations in older cancer survivors. We hypothesize that older cancer survivors have more functional limitations compared to non-cancer participants.

SA2: Evaluate the impact of functional limitations on healthcare utilization among older cancer survivors. We hypothesize that cancer survivors with functional limitations have increased healthcare utilization compared to those without it.

SA3: Examine the impact of physical limitations, functional limitations and self-assessed health status on healthcare utilization and mortality among older cancer survivors. We hypothesize that cancer survivors with physical and functional limitations will have worse self-assessed health status and both self-assessed health and physical and functional limitation will independently predict healthcare use and the risk of mortality among older cancer survivors. Furthermore, individual characteristics such as lifestyle factors and number of comorbidities may be modifiable factors associated with self-assessed health.

Study cohort and data sources

Data from the Medicare Current Beneficiary Survey (MCBS) from year 2006 to 2013 will be used to form the study cohort (Medicare current beneficiary survey (MCBS).2016). The MCBS is a nationally representative longitudinal, stratified, multi-stage survey of the entire older Medicare beneficiaries. The survey is administered by the Centers for Medicare and Medicaid Services (CMS). It is representative of the health and healthcare expenditure of Medicare beneficiaries. Three interviews were conducted each year over a period of four years to track health status changes and health care use among older Medicare beneficiaries. In the first interview, baseline information including demographics, medical history, health status and healthcare use information was gathered and assessed annually. During the fourth interview year, information from previous years was verified; therefore, longitudinal data is available for three consecutive years. Many outcomes are assessed for each respondent, but functional status is assessed only in the first two years of follow-up. These data are linked to Medicare claims file in the sample with fee for service Medicare coverage for the entire follow up period. In each Fall round of the year, one third of survey participants are rolled out and replaced by an equivalent number of new participants. Sampling weights are also provided for analytical purposes which account for the complex sampling design and non-response. This design allows the results to be generalized to the U.S. population (Wee et al., 2011).

In this study, we will use information on demographic and socioeconomic characteristics, health status, and limitations in physical activity of patients collected during each fall round of survey. Information collected in other rounds mainly focuses on access to health care and health care use during the year, which will also be used in this

study. We will restrict our study cohort to participants aged 65 or older and will exclude people who were diagnosed with cancer within one year before the baseline survey or developed new cancer during the study period and died during the survey years because their health needs and disabilities might differ from that of other survivors. In the final cohort, we will include only those who have at least one follow up interview during the study period, i.e., those who started in fall rounds of 40, 43, 46, 49, and 52. Thus, some participants may have three visits while others may have only two. Participants with missing values for functional limitations will also be excluded from the final cohort. The final sample will consist of participants, representing a weighted total of older Medicare beneficiaries (Medicare current beneficiary survey (MCBS).2016).

Assessment of functional limitations

The MCBS measures self-reported physical and functional limitations including ADL and IADL. Each functional limitation domain included five to six items, and each item is measured on a five-point scale. Physical limitations include - difficulty in stooping/crouching/kneeling, walking ¼ miles, reaching/extending arms above shoulder, lifting/carrying 10 lbs., and writing/handling objects. IADL limitations include - difficulty in using telephone, shopping, doing light and heavy house work, preparing meals, and paying bills. ADL limitations include difficulty in bathing, dressing, walking in the house, eating, getting in and out of chair or bed, and using toilet. Instead of scoring each item and creating a summary score which is typically used in most model adjustments, we will classify responses with “a lot of difficulty” or “not able to do it” as having a limitation, since the score distributions are skewed. Participants with two or more functional limitations in each domain were classified as

having physical functional limitation, ADL, or IADL limitations, respectively. Participants having one or more functional limitation i.e. physical, ADL, or IADL limitations will be defined as having "any limitation"(Katz, 1983; Lawton & Brody, 1970)

Demographic variables

The final cohort will include social-demographic characteristics such as age at the first survey, grouped as 65-74, 75-84 and 85 or older, sex, income (<$15,000, $15,000 - $30,000 and ≥$30,000), and race/ethnicity (White, African-American and Other). The number of comorbidities will be determined based on the number of clinical conditions in the final sample which will include heart disease, stroke, arthritis, chronic obstructive pulmonary disease (COPD), paralysis/amputation, bone disease, diabetes and hypertension.

Statistical methods

We employed propensity score analysis method based on the potential outcome causal inference framework (Rubin, 2004) to obtain correct estimate of average differences in the prevalence of physical and functional limitations between cancer survivors and people without cancer. We first conducted a logistic regression using the baseline data with cancer status as the dependent variable, and age, race, sex, income level, and all comorbidities as independent variables. As suggested by DuGoff et al, the survey stratum and survey weight were also included as predictors in the logistic regression model, but the propensity score model was not weighted (DuGoff, Schuler, & Stuart, 2014). The propensity score (P), i.e., the estimated probability of potentially

having a cancer diagnosis for both cancer patients and people without cancer, was estimated from the equation given below:

$$P = \frac{1}{(1 + e^{-(predicted\ log\ odds)})}$$

We then calculated a new propensity score weight, defined as 1/P for cancer patients, and 1/(1-P) for people without cancer and further calculated a new weight as the product of the original MCBS cross-sectional sampling weight and the new propensity score weight. This new weight deducted more on those participants who were in the tails of the propensity score distributions. Next, we multiplied the new weight with the average P for cancer patients or the average 1-P for people without cancer to correct the outliers in the new weights (also a form of stabilized weight) (Guo & Fraser, 2015). The final new weights were then used for comparing physical and functional limitations between cancer survivors and those without cancer in all the analyses. The socio-demographic characteristics and comorbidities were assessed using weighted mean and standard error (SE) for continuous variables and weighted frequency and percentage for categorical variables, and the group comparisons were assessed by t-test and Rao-Scott χ^2 test, respectively.

Furthermore, we assessed potential confounding effect prior to the final outcome model specification using the Mantel-Haenszel stratification analysis. If the magnitude of confounding was >10%, the variable was considered as a confounder and was included into the final multivariable logistic regression model. Separate multivariable logistic regression models were used to estimate the independent effect of cancer status on all

limitations at baseline, adjusted for socio-demographic characteristics and comorbidities. The adjusted logistic models were then used to estimate the average predicted marginal probabilities of having limitations in each year. Similar process was employed for examining the health care utilization among cancer survivors.

Socio-demographic characteristics and comorbidities will be summarized for cancer survivors and people without cancer using weighted mean and standard error (SE) for continuous variables, and weighted frequency and percentage for categorical variables. The two groups will be compared using t-test and Rao-Scott χ^2 test, respectively. The Rao-Scott χ^2 test will be applied since survey weights will be used for the survey-based design analysis. The weighted prevalence of various functional limitations according to cancer status will be compared using Rao-Scott χ^2 test. The independent effect of cancer status on each of the three limitations at the baseline will be estimated using separate multivariate logistic regression models where we will be adjusting for socio-demographic characteristics and comorbidities. Zero inflated Poisson regression models will be used for count data, e.g.: number of hospitalizations, >3 emergency department visits for specific aim 2. The average predicted probabilities of having limitations in each year will also be estimated in a similar way using logistic regression, adjusting for socio-economic characteristics and comorbidities. For specific aim 3, multivariate logistic regression and mixed model with repeated measures will be used to explore the differences and changes in self-assessed health status by functional limitations and their impact on healthcare use among older cancer survivors and survival analysis will be used for predicting the risk of mortality in them. The adjusted and unadjusted odds ratios for all the respective variables will be presented in tables. All analyses will be based on the multi-stage survey design models with appropriate

subpopulation (domain) analysis and weights using SAS version 9.4 (Surveyfreq, Surveymeans, and Surveylogistic). A p value of 0.05 will be set for statistical significance ($p<0.05$).

Future directions for cancer survivors research

Future work should include more constructed definitions of functional limitations, such as combining ADL with IADL difficulties among the older adult population. It is vital to develop interventions to address the unmet needs in this population and to measure the effect of disability on their overall health. Future studies will need to illustrate interventions to enhance and maintain functional independence at home among the older cancer survivors at different stages of life. These studies will play an important role in distinguishing the special needs and characteristics of different subpopulation by stages of disability. People with higher disabilities are more vulnerable to hospital readmissions. Therefore, we need to address the existing health disparities among this population and not just differences in health. Further research needs to examine the alternative health care use by cancer survivors, for example, home health care, hospice care, assisted living and so on.

Timely assessment of ADL and IADL will serve as a tool for clinicians, researchers and healthcare providers to make informed and shared decisions and maximize the health and functional ability of older Medicare population. Public health professionals need to develop interventions, which provide support to older cancer survivors and encourage them to retain their health and participate in social activities. This will not only reduce the level of functional limitation in them but will also enable these survivors to be a resource to others in the society. Further studies are required to find solutions to this problem, which will ultimately benefit the health of the entire older population.

CHAPTER 2

PHYSICAL AND FUNCTIONAL LIMITATIONS IN US OLDER CANCER SURVIVORS

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Abstract

Objective: The ability to independently perform daily activities is a crucial component of quality of life among older cancer survivors. However, many cancer survivors face difficulties performing their daily activities for living an independent life. The purpose of this study was to evaluate whether physical and functional status significantly decreased in cancer survivors compared to people without cancer.

Methods:

The Medicare Current Beneficiary Survey (MCBS) is a nationally representative longitudinal study for the entire aged Medicare beneficiaries. Data from 2006 to 2010 were used for analysis of this study. Design-based descriptive analysis and logistic models with adjusted survey weights were performed. To ensure comparability between cancer and non-cancer older adults, propensity score weighting was developed using logistic regressions.

Results:

The final sample consisted of 11,533 participants. Cancer survivors had more limitations compared to non-cancer individuals: physical limitations (23.3% vs. 19.7%, p = 0.006), activity daily living limitations (ADL) (7.7% vs. 5.8%, p=0.02), and instrumental activity of daily living limitations (IADL) (13.5% vs. 11.0%, p = 0.02. The odds ratio (OR) for cancer survivors compared to non-cancer individuals was 1.62 (95% CI: 1.28-2.06) for physical limitations, 1.08 (95% CI: 0.72-1.62) for ADL, and 1.30 (95% CI: 0.97-1.73) for IADL. There was a one-year lag in functional limitations resulting in one-year loss of physical capabilities among cancer

survivors. However, these differences between cancer and non-cancer participants decreased over the follow-up year (p=0.01).

Conclusion:

Cancer survivors have higher prevalence of physical and functional limitations compared to non-cancer individuals. Such disparities in functional limitations impact the independent functioning of these survivors. Healthcare professionals need to recognize potential for debilitating functional abilities among cancer survivors and address their needs. Our findings extend our understanding of the burden of physical and functional limitations in cancer survivors and call for action from health care providers.

Introduction

More Americans now live with cancer than before, with 15.5 million cancer survivors in 2016 and an estimated 20.3 million by 2026 (Miller et al., 2016). Almost two-thirds of them are 65 years or older (de Moor et al., 2013). Older adult cancer survivors are challenged not only by cancer-related treatment complications, comorbidities, and psychosocial impairments but also by age-related physical degeneration and functional limitations (Stein, Syrjala, & Andrykowski, 2008). For example, older female cancer survivors who underwent surgical treatment reported more functional limitations than non-cancer females, which led to restricted independence in daily activities and lower quality of life (Sweeney et al., 2006).

Physical, functional, and psychosocial well-beings are important components of health-related quality of life (Mishra, Scherer, Snyder, Geigle, & Gotay, 2014). Physical

and functional limitations refer to the inabilities to perform essential daily tasks for living a worthwhile life at home. We classified activities like walking, lifting, stooping, and sitting as physical activities; activities of daily living (ADL) was classified by activities such as using toilet, dressing, bathing, eating, and walking around the house; and instrumental activities of daily living (IADL) was classified by activities such as using telephone, doing housework, preparing meals, paying bills, and shopping. Together these activities fulfil the basic human needs. Also, physical and functional limitations are inter-dependent. More physical limitations may lead to increased ADL and IADL, whereas limitations in ADL and IADL may cause social isolation and negligence in personal health, which may result in worse physical and mental health outcomes (Grov et al., 2010). In addition, other factors such as comorbidities and lack of caregivers may also affect the extent and the quality of daily living activities (Sklenarova et al., 2015). Patient satisfaction with medical care and quality of life differ based on severity of functional limitations. Knowledge about patient's activity of daily living could provide helpful insight into their quality of life (Bogner et al., 2015).

Previous studies have explored physical and functional limitations among cancer survivors (Hamama-Raz, Shrira, Ben-Ezra, & Palgi, 2015; Song et al., 2014; Yang et al., 2012), demonstrating that elderly individuals who were less engaged in physical activities were at increased risk of having functional limitations (Brach et al., 2003; Mishra et al., 2014). However, most previous studies were based on cross-sectional study designs or examined the functional limitation as summary indices (Becker et al., 2012; Roehrig, Hoeffken, Pientka, & Wedding, 2007). Some earlier studies did not adequately address

the comparability between cancer survivors and non-cancer older adults regarding age, comorbidities, and other confounders based on modern causal inference framework (Stenholm et al., 2015; Stewart et al., 1977). A thorough understanding of physical and functional limitations among elderly cancer survivors may shed new light on targeted improvement in their quality of life.

In this study, we will examine physical and functional limitations among older adult cancer survivors using propensity score weighting to ensure comparability between those with and without a history of cancer diagnosis. We hypothesized that older cancer survivors have more physical and functional limitations and increased deterioration of functional status compared to non-cancer older adults.

Methods

Study cohort. We used the Medicare Current Beneficiary Survey (MCBS) data from the year 2006 to 2010. The MCBS is a nationally representative longitudinal, stratified, multi-stage survey of the entire aged Medicare beneficiaries, administered by the Centers for Medicare and Medicaid Services (CMS). Three interviews are conducted each year over a period of four years to track health status changes and health care use among older adult Medicare beneficiaries (MCBS,). The MCBS conducts interviews using a questionnaire version appropriate to the setting based on whether the sample person resides at home or in a long-term care facility. In Fall season of each year, one third of survey participants are rotated out and replaced by an equivalent number of new participants. The representative MCBS sample is selected through a three-stage process, the first stage includes selection of primary sampling units consisting of

metropolitan statistical areas or clusters of non-metropolitan counties. The second stage includes sampling of zip code clusters with primary sampling units and in the third stage beneficiaries are sampled within the zip code clusters. The MCBS oversamples individuals less than 65 years of age and greater than 80 years of age to increase the precision estimates of the above mentioned three groups. In this study, we used information on demographic and socioeconomic characteristics, health status, and physical and functional limitations of participants collected during each Fall round of the survey. Information collected in other rounds mainly focuses on access to health care and health care utilization during the year, thus was not used in this study.

We restricted our study cohort to participants aged 65 years or older (n=22,915 at baseline) and excluded people who were diagnosed with cancer within one year prior to the baseline survey, those who developed new cancer during the study period (n=821), and those who died during the survey years (n=1,458) because they might have different disabilities and health needs. Further, we included only those with at least one follow-up interview during the study period, i.e., those who interviewed in Fall rounds of the year and had additional interviews the following year (n=11,632). Thus, some participants had three visits while some only had two. Those with missing values in functional limitations (n=99) were also excluded. Since the MCBS is a multi-stage survey design, it provides sample weights to adjust for the non-response rate. The sum of these sample weights provides an unbiased estimate of the total number of individuals in the target population. They are interpreted as the number of individuals in the target population and what each sample participant is estimated to represent. Our final sample consisted of 11,533 participants, representing a weighted total of 48,517,805 aged Medicare beneficiaries.

Measuring physical and functional limitations

Each year the MCBS measures self-reported physical and functional limitations activities of daily living and instrumental activities of daily living (Schüssler-Fiorenza Rose et al., 2016) (Table 2). Each limitation domain includes five or six items, and each item is measured on a five-point scale. Based on the measurement questionnaire we classified physical limitations as difficulty in stooping/crouching/kneeling, walking ¼ miles, reaching/extending arms above shoulder, lifting/carrying 10 lbs., and writing/handling objects; ADL limitations included difficulty in bathing, dressing, walking in the house, eating, getting in and out of chair or bed, and using toilet; and IADL limitations included difficulty in using telephone, shopping, doing light house work, preparing meals, and paying bills. The distribution of score in each item was highly skewed, typically only 10-20% scored "a lot of difficulty (4)" and "not able to do it (5)". The summary score was highly skewed as well. Thus, we did not create a measurement scale based on summary score which is often used in model adjustment. We classified any item response with a score of 4 or 5 as having a limitation. We then further classified having two or more limitations in each domain as having a functional limitation. Participants having at least one ADL or IADL limitations were defined as having 'any functional limitations'.

Measuring demographic variables, cancer status, and comorbidities

The MCBS collects socio-demographic and health status information during the face-to-face interviews. We included socio-demographic characteristics such as, age at baseline survey (recoded as 65-74, 75-84, and 85 or older), gender, income (<$15,000,

$15,000 - $30,000, and ≥$30,000), and race/ethnicity (recoded as Caucasian, African-American and Other). History of cancer diagnosis was assessed in questions such as "ever told having a non-skin cancer", "had a cancer past year" and body part (site) of cancer. Consistent with the definition adopted by National Cancer Institute, we defined cancer survivors as those having survived cancer from the time of cancer diagnosis until end of life (National cancer institute.2015). Those with non-melanoma skin cancer were not considered cancer survivors because of the non-invasiveness of cancer.

The number of comorbidities was based on the number of self-reported clinical conditions, including heart disease, stroke, arthritis, chronic obstructive pulmonary disease (COPD), paralysis/amputation, bone disease, diabetes, hypertension, psychiatric disorder, neurological disease including dementia and Alzheimer's disease, recorded as yes or no on the questionnaires. Multiple chronic conditions were defined as having two or more of the above chronic conditions, excluding hypertension due to its high prevalence. This is similar to other comorbidity measures such as Charlson's Index in which hypertension is not considered (Charlson, Pompei, Ales, & MacKenzie, 1987).

Statistical Analysis

We adopted the potential outcome causal inference framework (Rubin, 2004) and employed propensity score methods to obtain a correct estimate of average differences in physical and functional limitations between cancer survivors and people without cancer. We generated a quadratic term age^2 to determine the effect of age on the outcome based on each year. We included the squared term in the analyses because each year's age

effect might be non-linearly related to the cancer status of individuals. The age^2 was to capture the complicated relationship between age and cancer status. Specifically, we first conducted a logistic regression using baseline data with cancer status as the dependent variable, and age, age^2, race, sex, income level, and all comorbidities as predictors. In addition, as suggested by DuGoff et al., the survey stratum and survey weight were also included as predictors in logistic regression but were not weighted in the model for propensity score analysis (DuGoff et al., 2014). The propensity score (P), i.e., the estimated probability of potentially having a cancer diagnosis for all participants, was estimated from logistic regression as follows:

$$P = \frac{1}{(1 + e^{-(predicted\ log\ odds)})}$$

We then calculated a new weight as the product of the original MCBS cross-sectional sampling weight and 1/P for cancer survivors, or 1/(1-P) for people without cancer. This new weight discounted more on those participants who were in the tails of propensity score distributions. In addition, we also multiplied the new weight with the average P for cancer survivors or the average 1-P for people without cancer to correct the outliers in the new weights. All analyses were then weighted by the final weight.

The distributional balance of socio-demographic characteristics and comorbidities between cancer survivors and people without cancer was assessed using weighted mean and standard error (SE) for continuous variables, and weighted frequency and percentage for categorical variables, using t test and Rao-Scott χ^2 test, respectively. The weighted prevalence of various limitations by cancer status was compared using Rao-Scott χ^2 test

as well. The independent effect of cancer status on each of the limitations was estimated at the baseline with separate multivariate logistic regression models adjusting for socio-demographic characteristics and comorbidities. The average predicted marginal probabilities of having limitations in each year were similarly estimated using logistic regression, adjusting for socio-demographic characteristics and comorbidities.

All analyses were based on the multi-stage survey design with appropriate subpopulation (domain) analysis and with the above new weights using SAS version 9.4 (SURVEYFREQ, SURVEYMEANS, and SURVEYLOGISTIC). A more stringent p value for statistical significance ($p<0.01$) was used to take account of multiple comparisons in Table 2 and 3.

Results

There were 17.6% of participants who were diagnosed with cancer at least one year before the baseline survey, i.e., cancer survivors. Table 1 describes socio-demographic characteristics and comorbidities of participants and assesses the balance of these factors by cancer status after propensity score weighting. Overall, there was no significant difference in these factors by cancer status. The weighted mean age was 75, about 58% were females, 8% were African Americans, and 24% lived with a median income <$15,000 for both groups. Except for bone diseases, there was no statistical difference in the prevalence of various self-reported comorbidities, though cancer survivors had a slightly higher prevalence of most comorbidities. About 58% of cancer survivors had multiple chronic conditions (two or more comorbidities excluding

hypertension). This suggested that the goal of balancing confounders between groups using propensity score methods was achieved.

Table 1: Description of sociodemographic characteristics of Older Medicare Cancer Survivors and Enrollees without cancer

Characteristics	Cancer survivors (weighted: 17.6%) N = 1,890	People with no cancer (weighted: 82.4%) N =9,643	P-value
Age (Mean, SE)	74.6 (0.20)	74.7(0.07)	0.60
65 to 74	55.4	54.4	
75 to 84	35.4	35.5	0.68
≥ 85	10.2	10.1	
Gender			
Male	42.0	43.4	0.41
Female	58.0	56.6	
Race/ethnicity			
Caucasian	86.5	87.4	
African American	7.8	8.1	0.43
Other	5.7	4.6	
Income (per year)			
<$15,000	24.0	23.0	
$15,000 to $30,000	33.8	33.4	0.63
≥ $30,000	42.2	43.6	
Comorbidities			
Heart Disease	40.8	41.3	0.76
Stroke	9.9	9.8	0.84
Arthritis	62.2	59.0	0.03
COPD	16.3	15.2	0.23
Paralysis/Amputation	3.9	3.0	0.04
Bone Disease	26.9	22.7	0.004
Diabetes	18.9	18.1	0.51
Hypertension	67.4	65.4	0.23
Neurological disease	9.7	9.3	0.63
Psychological disease	10.2	9.1	0.28

Multiple chronic conditions (>=2)	58.1	56.7	0.38
Site of Cancer			
Lung	3.8	NA	
Breast	29.2	NA	
Prostate	22.5	NA	
Colon	11.9	NA	
Kidney	2.4	NA	
Other cancer	30.2	NA	

Note: Unweighted N = 11,533, weighted N = 48,517,805;

Cancer survivors: Unweighted N =1,890; Weighted N = 8,523,945;
People without cancer: Unweighted N = 9,643; Weighted N = 39,993,860.

Table 2 presents the weighted prevalence of physical, ADL and IADL limitations at the baseline survey by cancer status. Elderly cancer survivors were more likely to experience limitations in all three domains than those without cancer. Cancer survivors had higher prevalence of having two or more physical limitations (23.3% vs. 19.7%, p=0.006). Among physical limitations, except for difficulty in walking and writing, difficulties in other physical tasks were significantly higher among cancer survivors compared to non-cancer participants. Difficulty in stooping was the most common physical limitation seen in 30.9% of cancer survivors. Similarly, slightly higher prevalence of ADL limitations was also seen in cancer survivors than non-cancer participants (7.7% vs 5.8%, p =0.02). Difficulties in preparing meals (p=0.002) and shopping (p = 0.008) were significantly more prevalent in cancer survivors than those without cancer. Finally, cancer survivors were also more likely to have IADL limitations (13.5% vs. 11.0%, p=0.02), especially difficulties in bathing, using the toilet and getting in and out of chair. When all limitations were combined, cancer survivors were

significantly more likely to have 'any limitations' (28.1%) than people without cancer without (23.3%, p=0.0005).

After adjusting for age, socio-demographic characteristics, comorbidities, and site of cancer, cancer survivors were more likely to have physical limitations than older adults without cancer (adjusted odds ratio (OR): 1.62 [95% confidence interval (CI): 1.28 – 2.06]), whereas there was no statistical difference in ADL limitations (OR: 1.08 [0.72 – 1.62]) and IADL limitations (OR: 1.30 [0.97 – 1.73]) (Table 3). Overall, cancer survivors were 61% more likely to have any limitations than people without cancer (OR: 1.61 [1.29 – 2.02]). In addition, older age was significantly associated with higher prevalence of physical and functional limitations. Females and participants with higher income level were significantly less likely to have physical and functional limitations. Participants with multiple chronic conditions were about four times more likely to have physical and functional limitations than those without multiple comorbidities. There was no significant association between cancer types and functional limitations (Table 3).

Table 2: Physical, Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) Limitations among Older Medicare Beneficiaries, Cancer Survivors and People without Cancer.

Functional Limitations	Cancer survivors (weighted %)	People without cancer (weighted %)	P-value
Two or more physical limitations	23.3	19.7	0.006

Difficulty in stooping/crouching	30.9	26.3	0.0005
Difficulty in walking ¼ miles	23.4	21.2	0.11
Difficulty in reaching/extending	8.9	6.1	0.0008
Difficulty in lifting 10 lbs.	14.9	11.8	0.003
Difficulty in writing/handling objects	4.1	4.5	0.47
Two or more IADL limitations	7.7	5.8	0.02
Difficulty in using telephone	5.3	4.4	0.18
Difficulty in doing light housework	7.4	5.6	0.02
Difficulty in preparing meals	6.2	3.9	0.002
Difficulty in shopping	9.1	6.8	0.008
Difficulty in paying bills	3.5	2.8	0.24
Two or more ADL limitations	13.5	11.0	0.02
Difficulty in bathing	8.5	6.8	0.03
Difficulty in dressing	4.9	4.4	0.42
Difficulty in eating	1.5	1.2	0.33
Difficulty in walking in the house	21.4	19.3	0.11
Difficulty in using toilet	4.2	3.1	0.05
Difficulty in getting in and out of bed or chair	11.8	9.3	0.01
Any limitations	28.1	23.3	0.0005

Table 3: Adjusted odds ratios Multivariable Analysis of Determinants of Functional Limitations at Baseline

Determinants	Adjusted OR (95% CI)			
	Two or more physical limitation	Two or more ADL limitation	Two or more IADL limitation	Any limitation

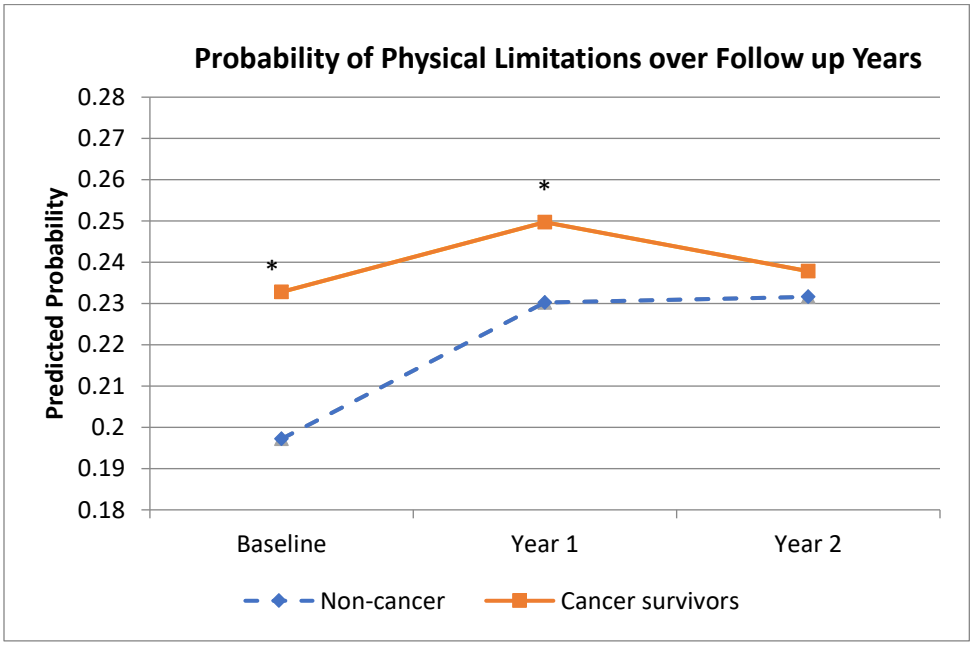
Cancer survivors vs. Non-cancer	1.62 (1.28 – 2.06)[a]	1.08 (0.72 – 1.62)	1.30 (0.97 – 1.73)	1.61 (1.29 – 2.02)[a]
Age (per year)	1.04 (1.03 –1.05)[a]	1.04 (1.03 – 1.05)[a]	1.04 (1.03 – 1.05)[a]	1.04 (1.03 – 1.05)[a]
Female vs. male	0.69 (0.61 – 0.78)[a]	0.71 (0.61 – 0.83)[a]	0.76 (0.65 – 0.88)[a]	0.74 (0.66 – 0.83)[a]
African American vs. Caucasian	1.01 (0.82 – 1.23)	1.45 (1.11 – 1.89)	1.14 (0.94 – 1.39)	1.03 (0.86 – 1.22)
Income (ref: <$15,000 per year)	--	--	--	--
$15,000 - $30,000	0.70 (0.62 – 0.80)[a]	0.67 (0.53 – 0.85)[a]	0.74 (0.61 – 0.89)[a]	0.68 (0.59 – 0.78)[a]
≥ $30,000	0.36 (0.31 – 0.42)[a]	0.34 (0.25 – 0.45)[a]	0.48 (0.40 – 0.58)[a]	0.37 (0.32 – 0.43)[a]
Comorbidity [≥2 vs. <2]	4.30 (3.31 – 4.99)[a]	4.92 (3.94 – 6.16)[a]	4.62 (3.88 – 5.51)[a]	4.33 (3.80 – 4.95)[a]
Site of Cancer (compared with non-cancer)				
Lung	0.77 (0.42 – 1.39)	0.95 (0.44 – 2.08)	0.93 (0.51 – 1.71)	0.79 (0.45 – 1.38)
Breast	0.71 (0.49 – 1.02)	1.62 (0.84 – 3.13)	1.03 (0.71 – 1.49)	0.76 (0.55 – 1.06)
Prostate	0.52 (0.36 – 0.75)[a]	1.36 (0.71 – 1.58)	0.86 (0.55 – 1.35)	0.66 (0.46 – 0.94)
Colon	0.71 (0.47 – 1.07)	0.81 (0.41 – 1.60)	0.94 (0.61 – 1.44)	0.71 (0.49 – 1.04)
Kidney	0.67 (0.28 – 1.58)	0.54 (0.10 – 2.83)	0.67 (0.13 – 1.58)	0.84 (0.35 – 2.00)

Abbreviations: OR: Odds Ratio, CI: Confidence Interval
Models were adjusted for age, race, sex, income, medical comorbidities, site of cancer, and first entrance round to the survey
[a]$p<0.01$;

Figure 4a to 4d showed the predicted probabilities of having physical and functional limitations over the follow up years after adjusting for age, socio-demographic characteristics and comorbidities. Cancer survivors always had higher probabilities of physical and functional limitations than people without cancer. Although the probabilities of having various limitations remained stable among cancer survivors, they increased over the follow up years among people without cancer. The differences of probabilities between cancer survivors and non-cancer participants were most evident at baseline, with

significant differences seen in physical limitations ($p<0.01$). However, such differences decreased over the follow up years and by the third year, the probabilities of limitations between the two groups were similar. In addition, when we limited the analysis to participants who had completed three years of follow up, results were similar, thus the above patterns were not due to attrition of the sample at year three.

Figure 4a: Adjusted predicted probability of physical limitations over follow up years



(*) indicates $p<0.01$comparing cancer survivor with no cancer elderly people

Figure 4b: Adjusted predicted probability of ADL limitations over follow up years

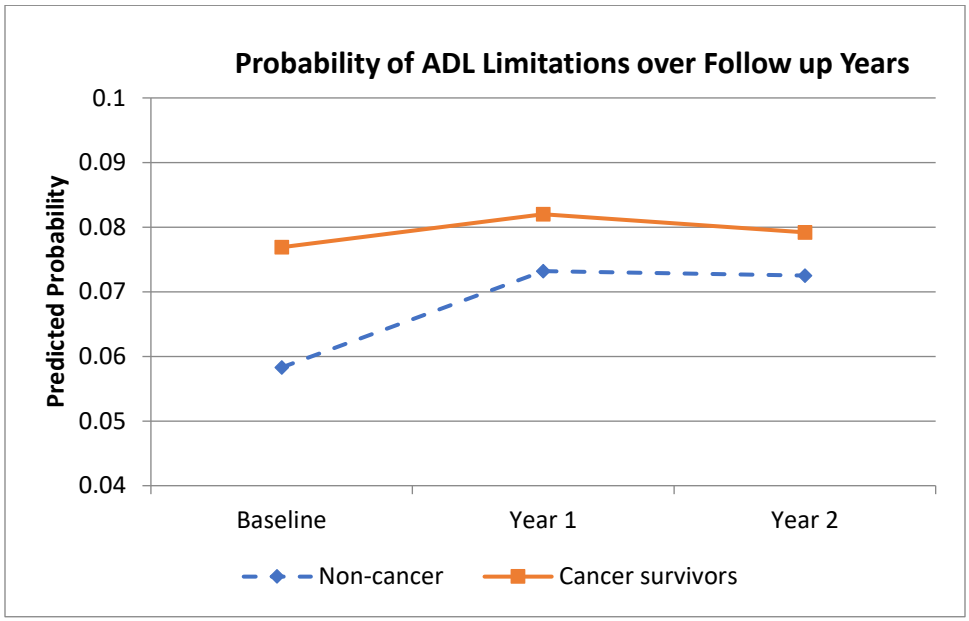


Figure 4c: Adjusted predicted probability of IADL limitations over follow up years

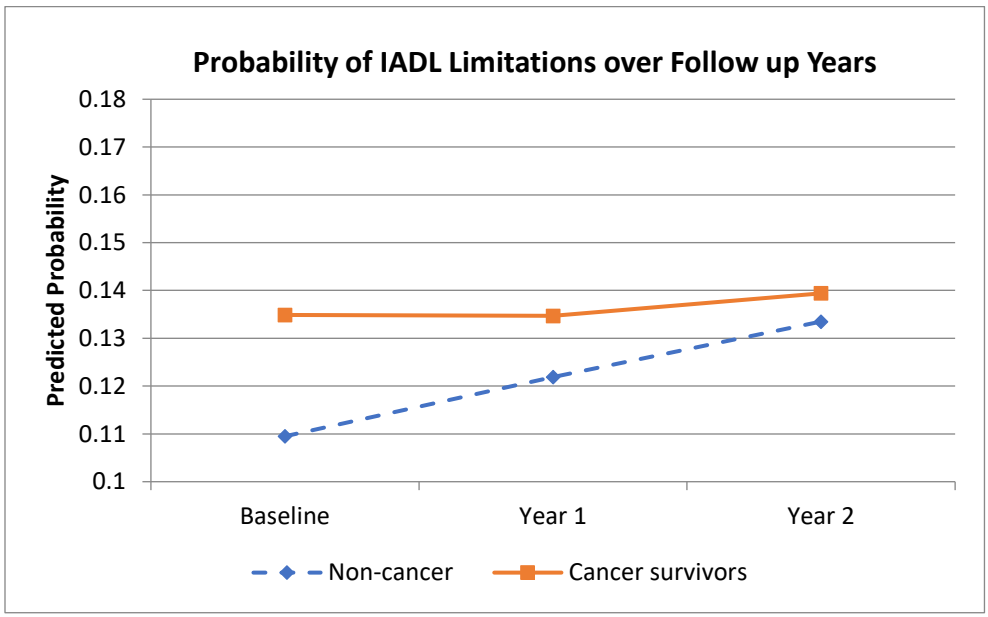
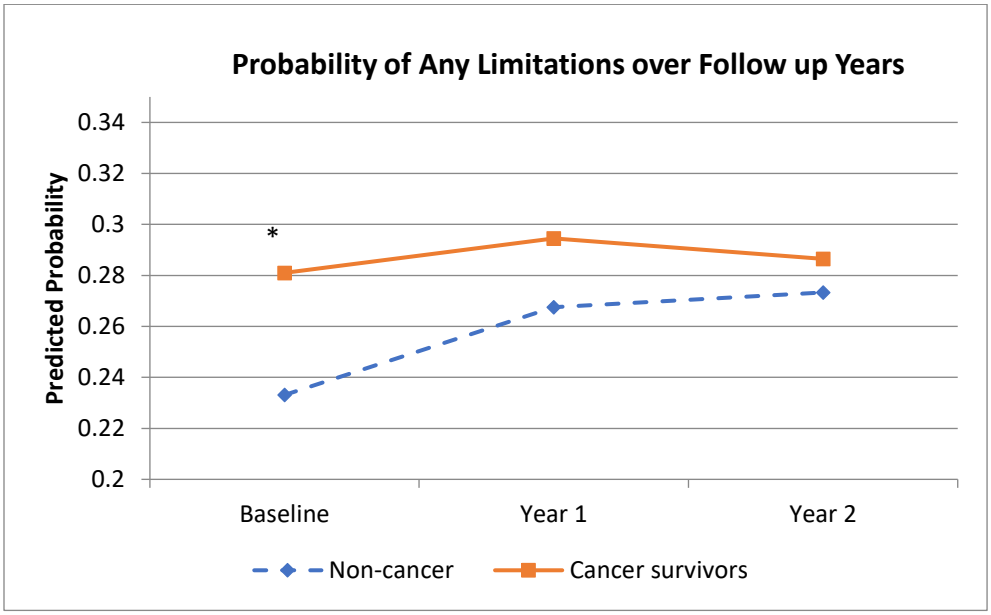


Figure 4d: Adjusted predicted probability of any limitations over follow up years



Predicted probabilities were adjusted for participant's sociodemographic, comorbidities. Star (*) indicates p<0.01 for comparing cancer survivors with those without cancer.

We conducted additional sensitivity analysis regarding the impact of comorbidities on physical and functional limitations. When all comorbidities entered the multivariate model as individual terms, cancer survivors still had significantly higher physical limitations than people without cancer but not for ADL and IADL limitations. The time trends of predicted probabilities were similar to the figure 4a-4d as well. Furthermore, after restricting our sample to those without multiple comorbidities (defined as two or more comorbidities), results were similar but non-significant due to smaller sample size. About 2.9% of cancer survivors had any limitations, compared with only 1.7% among elderly with no cancer (p=0.11), and the differences for physical limitations were (8.8% vs. 7.9%, p = 0.39), for ADL limitation (2.2% vs. 1.7%, p=0.54), and (4.3% vs. 3.7%, p =0.48) for IADL limitations.

Discussion

Our study demonstrated that older cancer survivors suffered more physical and functional limitations in their daily activities than those without cancer. Such disparities negatively impact the ability of independent living at home among older cancer survivors. In addition, there was about one-year difference in the probability of having functional limitations between cancer survivors and non-cancer individuals, suggesting that public health interventions at an early stage may improve the quality of life in this population.

Several studies have examined the differences in health status of cancer survivors (Serraino et al., 2001; Yang et al., 2012), and a few have assessed the age-related and cancer-related functional impairment, comorbidities, and other psychological problems. Hamama-Raz et al. reported a stronger reciprocal relationship between functional limitations and quality of life among cancer survivors above 75 years of age (Hamama-Raz et al., 2015), and Wolinsky et al. also showed a decline in activities of daily living among older adult cancer survivors with greater odds of functional decline before one year of death (Wolinsky et al., 2011). Our results are in line with these previous studies.

Our findings enhanced the understanding of the burdens of physical and functional limitations among cancer survivors. Previous studies have shown that older cancer survivors face physical, emotional, and social challenges in their daily lives (Stineman, Margaret G. et al., 2014; Wolinsky et al., 2011). By examining the patterns of limitations and exploring items in each domain, we could identify key barriers faced by

older cancer survivors in their daily lives. We found that physical limitation activities were instrumental in affecting cancer survivor's mobility and independence. The higher prevalence of physical limitations among older cancer survivors may be due to the impact of cancer and its treatment on physical functions of the body, as cancer related surgery, chemotherapy, and radiation therapy may have an impact on the physical functions and can often lead to some irreversible changes in the body. ADL and IADL limitations among non-cancer older adults, were also related to impaired physical functioning of the body.

Furthermore, cancer survivors were more likely to have multiple comorbidities (Leach et al., 2015; Stenholm et al., 2015). On an average a long-term cancer survivor has five medical comorbidities (Leach et al., 2015) and most comorbidities and disabilities have been associated with poor mental and physical health (Song et al., 2014). In some of these individuals, identifying patterns and mechanisms of functional limitations, preventing or slowing the progression of symptom deteriorations, and improving quality of life may be more important than the treatment of the disease.

Our study suggested a one-year loss of physical capacity due to cancer-related disabilities, as predicted in the figures showing the prevalence of physical and any functional limitations. Again, this may be due to the inevitable consequences of cancer and its treatment on physical functioning of the body. Such differences negatively affect the quality of life among cancer survivors. For instance, cancer survivors had difficulties in shopping, preparing meals and getting in and out of bed and chair. However, since there is a one-year lag between cancer survivors and non-cancer individuals, physical and

functional limitations among older cancer survivors could be improved through physical therapy and muscle strengthening activities to regain physical strength and function, as demonstrated by two previous studies (Burnham & Wilcox, 2002; Mishra et al., 2014).

In addition, health care needs for older cancer survivors tend to be more disintegrated and disorganized. Health care providers, including oncologists, primary care physicians, and geriatricians, should pay more attentions to the functional status of older cancer survivors during their clinic visits. Coordinating follow up care and adequately addressing their health needs during subsequent visits can be challenging (Jacobs & Shulman, 2017), due to limited time slot for each clinic visit and competing demands in managing various chronic conditions (Williams, 1998). However, some measures of functional limitations should be made as a part of the routine cancer survivorship care. Risk estimation for physical and functional limitations should be developed (McCabe et al., 2013), which helps devise more coordinated and tailored care plan for older adult cancer survivors.

The most important strength of our study is our analysis which is based on the modern causal inference theory. We adopted the potential outcome framework and used propensity score methods to ensure that cancer survivors and those without cancer were comparable in key confounders. The unadjusted prevalence of physical and functional limitations presented in Table 2 were adjusted implicitly through propensity score weighting and were un-confounded by variables we presented in Table 1. Another main strength of the study is that MCBS is a nationally representative survey and we obtained

a complete profile of both physical and functional limitations experienced by the older population, therefore inferences from this study can be applied to the older adult cancer survivor population.

This study also has a few limitations. The MCBS questionnaires did not have detailed cancer staging, disease severity, stage of recovery, and treatment information. Differences in these factors can lead to different trajectories of physical and functional limitations. The age of cancer diagnosis was not available except an indicator of whether cancer was diagnosed during the past year of the survey conducted. Thus, we were not able to identify long-term cancer survivors (survived 5 or more years after diagnosis). In addition, the measures of outcomes and exposures were self-reported and might be subject to recall or interview bias. Propensity score analysis cannot take account of unmeasured confounders, if some of the important confounders are unmeasured, the estimates may be still biased. The data presented in this study is 7 years old so, these individuals must have received anti-neoplastic therapies over 10 years ago. Today, there may be greater efforts towards improved survivorship care planning that mitigate these limitations; nonetheless, there is a need to identify and manage these limitations in a more proactive manner.

Cancer survivors now live longer due to early detection of cancer, and improved cancer treatment. But they have more physical and functional limitations than those without cancer, resulting in an equivalence of one-year loss of physical and functional capacities. Although this difference is disconcerting, it can be reduced through targeted

interventions such as prehabilitation training programs and guided physical exercise training. Furthermore, the need for devising an optimal care plan for older cancer survivors is critical. Our study calls for health care providers to incorporate formal assessments of functional status and quality of life into their regular clinical practice.

Strengths and Limitations

The main strength of the study is that MCBS is a national survey. We obtained a complete profile of both physical and functional limitations experienced by the older population who have survived cancer for more than a year. Our study also had an advantage over many previous cross-sectional studies since we used the follow up data to determine the one-year difference in the physical and functional status between cancer survivors and those without cancer. Finally, the most important strength is that our analysis is based on the robust modern causal inference theory. We adapted the potential outcome framework and used propensity score methods to ensure that cancer survivors and those without cancer were comparable in key confounders. The unadjusted prevalence of physical and functional limitations presented in Table 2 were adjusted implicitly through propensity score weighting and were un-confounded by variables we presented in Table 1.

This study also has a few limitations. The MCBS questionnaires did not have detailed cancer staging, disease severity, and treatment information. Differences in cancer stage, treatment, and stage of recovery can lead to different physical and functional limitations. There was also no information about the age of cancer diagnosis except an

indicator of whether cancer was diagnosed during the past year of the survey conducted. Thus, we were not able to identify long-term cancer survivors, i.e., those survived 5 or more years after diagnosis. In addition, the measures of outcomes and exposures were self-reported and might be subject to recall bias or interview bias. Also, for some participants, proxy answers given by close family members might differ from responses given by the participants themselves. Finally, although propensity score analysis in theory is preferred for causal inference, it cannot take account of unmeasured confounders. If some important confounders are omitted, the estimates may be still biased.

Conclusion

Cancer survivors now live longer due to early detection of cancer, improved cancer treatment, and better quality of care**,** but they have more physical and functional limitations than those without cancer, resulting in equivalent of one-year loss of physical capacities. Although this difference is disconcerting, such one-year loss of physical capacities may be improved through intervention studies. Physical therapy and guided physical exercise will help older cancer survivors maintain an independent living at home. Furthermore, as the number of cancer survivors continues to grow each year, the need for devising an optimal care plan for older cancer survivors is critical. Our study calls for health care providers to incorporate formal assessments of functional status and quality of life into their regular clinical practice.

CHAPTER 3

IMPACT OF PHYSICAL AND FUNCTIONAL LIMITATIONS ON HEALTHCARE UTILIZATION AMONG OLDER CANCER SURVIVORS IN U.S.

*This chapter has been reviewed and re-submitted to Journal of Aging & Health.

Abstract

Objective: This study examines effects of physical and functional limitations on healthcare utilization among older cancer survivors, compared to those without cancer and without physical and functional limitations.

Method: Medicare Current Beneficiary Survey data from 2008 to 2011 were used. Physical Limitations (PL), Activities of Daily Living (ADL), and Instrumental Activities of Daily Living (IADL) were measured on a five-point scale. Propensity score weighting was developed using logistic regressions.

Results: Older cancer survivors with physical and functional limitations had higher rate of emergency department visits than those without limitations (PL: 21.8%vs.17%, aOR:1.72, 95% CI: 1.26–2.35, $p<0.05$; ADL: 25.8%vs.17.4%, aOR: 2.68, 95% CI: 1.86–3.86, $p<0.001$) and higher cost of hospitalization (IADL: mean=$24,916, SD:3,877.1).

Conclusion: Older cancer survivors with physical and functional limitations had higher healthcare utilization compared to those without cancer. Addressing complex and unique healthcare needs in this population will help reduce excess burden on the healthcare system.

Introduction

Longevity among cancer survivors is steadily increasing over the past three decades. About 60% of cancer patients are expected to survive five or more years after cancer diagnosis (DeSantis et al., 2015) due to early detection of cancer, advanced medical technologies, newer treatments, and improved cancer follow-up care (Gotay & Muraoka, 1998; Sweeney et al., 2006). In 2018, the overall 5-year relative survival rate was 68% among Caucasians and 61% among African Americans. The cancer survivor population in the United States is expected to reach 20.3 million by 2026; and older cancer survivors account for almost two-thirds of this population (Siegel et.al., Cancer Statistics 2018). In addition, the estimated national expenditure of cancer care in 2017 was 147.3 billion dollars (National Cancer Institute, April, 2018). As the older cancer survivor population continues to increase, the healthcare-related cost is also likely to increase.

Older cancer survivors represent a vulnerable population who suffer from prolonged consequences of cancer and its treatments. They often receive fewer optimal cancer treatment options due to their frail conditions which may further deteriorate their overall well-being. They are also more likely to have multiple chronic conditions, thus experiencing additional physical and functional limitations compared to individuals without a history of cancer (de Moor et al., 2013; Hardy et al., 2010). Physical limitations (PL) and functional limitations (FL) are two key components related to healthcare of older cancer survivors. Physical limitations refer to the reduced strength to perform basic physical activities such as walking, lifting, stooping, sitting, etc. (Stineman, M. G. et al., 2014). Functional limitations refer to the inability to perform essential daily tasks to live a meaningful life at home (Field & Jette, 2007), which include both Activities of Daily Living (ADL) such as using toilet, dressing, bathing, eating, and walking

around the house; and Instrumental Activities of Daily Living (IADL) such as shopping, managing bills, and participating in events of social life (Katz, 1983; Lawton & Brody, 1970).

While the benefits of building physical capacities in this population have been established in literature (Stacey, James, Chapman, Courneya, & Lubans, 2015; Van Roekel et al., 2015; Johnson, Fallon, & Berg, 2019), not much is known about the effects of physical and functional limitations on healthcare utilization in this population. Compared to individuals with no history of cancer, cancer survivors are more likely to have functional limitations and poor health conditions (Hewitt, Rowland, & Yancik, 2003). Moreover, physical and functional limitations can be inter-related and affect each other. For instance, more physical limitations lead to increased limitations in ADL and IADL causing more dependence on caregivers to assist with daily tasks. In addition, these limitations may result in negligence of personal health and social isolation, which could further deteriorate physical and mental health among older cancer survivors (Grov et al., 2010).

Furthermore, older cancer survivors are more likely to use supportive medical services thus, have higher healthcare utilization than those without cancer. The national estimates of healthcare expenditure showed older cancer survivors with higher utilization rates of healthcare services, compared to other chronically ill patients (Bernard et al., 2011). Older cancer survivors not only had higher overall healthcare expenditure, but also had excess healthcare expenditure which continued even after many years of cancer diagnosis, compared to individuals without a history of cancer (Guy Jr et al., 2013). Fried et al. demonstrated that functional disability in older adults imposed a substantial burden on government healthcare services (Fried, T. R., Bradley, Williams, & Tinetti, 2001). They also argued that assessment of functional status was the best

predictor of healthcare expenditure in older people. In addition, since older cancer survivors are more likely to access supportive medical services, visit primary care physicians, and consult specialists (Weaver, Rowland, Bellizzi, & Aziz, 2010), more coordination between primary care physicians and other specialists is needed to address their complex healthcare needs. Providing care for older cancer survivors with physical and functional limitations also exerts a significant burden on the healthcare system, presenting new challenges and escalating already exorbitant healthcare cost (Heins, Schellevis, Rijken, van der Hoek, & Korevaar, 2012).

There are only a few population-based studies conducted so far about the effects of physical and functional limitations on healthcare utilization among older cancer survivors in the United States (Karve et al., 2015; Kurtz, Kurtz, Given, & Given, 2005; Manzano, Luo, Elting, George, & Suarez-Almazor, 2014). The broad picture suggested by these studies was that the healthcare utilization tended to increase with a decrease in physical and functional capacities among elderly cancer survivors with increased inpatient, emergency department visits and outpatient hospital visits being the primary drivers. However, most of these studies are descriptive in nature and not adequately designed to satisfy causal inference criteria. Therefore, prior research may under- or over-estimate the healthcare utilization among older cancer survivors. To fill this gap in literature, we examined the effects of physical and functional limitations on healthcare utilization among older cancer survivors compared to those without cancer, using propensity score analysis method. We hypothesized that older cancer survivors with physical and functional limitations had higher healthcare utilization compared to those without cancer and to those without limitations.

Data and Method

Study Cohort. Cost and Use files from Medicare Current Beneficiary Survey (MCBS) from 2008 to 2011 were used in this study. MCBS, administered by the Centers for Medicare and Medicaid Services (CMS), is a nationally representative longitudinal, rotating, multi-stage survey of the entire older Medicare beneficiaries. MCBS conducts three interviews each year over a period of four years to track health status changes and healthcare utilization among older Medicare beneficiaries. During each Fall round of survey, one third of participants are rotated out and replaced by an equivalent number of new participants. In the first interview, baseline information, including demographics, medical history, health status, and information on healthcare utilization, is collected. During the third interview each year, information from previous years is verified; therefore, longitudinal data are available for up to three consecutive years. Various outcomes are assessed for each respondent, but functional status is assessed only in the first two years of follow up. Both cross-sectional and longitudinal survey weights are provided for analytical purposes to account for the complex sampling design and non-response in the surveys. The weighted summary statistics represent those of targeted populations (Medicare current beneficiary survey (MCBS).2016).

In this study, we used information on socio-demographic characteristics, health status, physical limitations, and functional limitations (ADL and IADL) collected during each Fall round of survey. Information collected in other rounds on access to healthcare and healthcare utilization were also used in this study. We restricted our study cohort to participants aged 65 years or older (n = 23,695 at baseline) and excluded participants who were diagnosed with cancer within one year prior to the baseline survey or those who developed new cancer during the study period (n=821), and those who died during the survey years (n=1,458) to create a

relatively homogeneous study sample to measure the outcomes of healthcare utilization during the end of life period. Although it could lead to survival bias among cancer survivors and may underestimate the true differences between cancer survivors and those without cancer, our study cohort is more likely to represent long-term cancer survivors. We also included only those participants who had at least one follow-up interview during the study period. In addition, participants enrolled in Health Maintenance Organization (n=8,736) and those with missing values for functional limitations (n = 99) were also excluded from the final cohort. No imputation strategy was applied in the analyses due to small percentage of missing values. Our final sample consisted of 23,695 participants, representing a weighted total of 110,086,170 older Medicare beneficiaries.

Assessment of physical and functional limitations

MCBS includes measures for self- reported physical limitations and functional limitations (ADL & IADL). Physical limitations (PL) include difficulties in stooping/crouching/kneeling, walking ¼ miles, reaching/extending arms above shoulder, lifting/carrying 10 lbs., and writing/handling small objects. Functional limitations include ADL and IADL. ADL limitations include difficulties in bathing, dressing, walking in the house, eating, getting in and out of chair or bed, and using the toilet, and IADL limitations include difficulties in using telephone, shopping, doing light house work, preparing meals, and paying bills. Each domain includes five or six items and each item is measured on a five-point scale (1 = no difficulty, 2 = a little difficulty, 3 = some difficulty, 4 = a lot of difficulty, 5 = unable to do it). Since the score for each item had a distribution with a long right tail (i.e. small number of people had a large score of 4 or 5 while the majority had a score of 0 or 1.), we dichotomized each item into a binary variable.

Responses to questions with “a lot of difficulty” or “unable to do it” were considered as having a physical limitation or functional limitation for that item. For each domain of limitations, having two or more (out of total five or six) item-wise limitations was considered as having a limitation. This method is consistent with the International Classification of Functioning, Disability, and Health (ICF) created by Institute of Medicine in 1991(Pope & Tarlov, 1991).

Socio-demographic characteristics and health status

MCBS also collects information on socio-demographic characteristics and health status during the face-to-face interviews. Socio-demographic characteristics include age at baseline survey (regrouped as 65-74 years, 75-84 years, and 85 years or older), gender, income (<$15,000, $15,000 - $30,000, and ≥$30,000), and race/ethnicity (regrouped as Caucasian, African-American, and Other). Consistent with the definition adopted by National Cancer Institute, we defined cancer survivors as those having survived cancer from the time of diagnosis until their end of life (National cancer institute.2015). History of cancer diagnosis was assessed through questions such as “ever told having a non-skin cancer”, “had a cancer past year” and site (body part/organ) of cancer. Those with non-melanoma skin cancer were not considered cancer survivors in this study because of the nature of non-invasiveness of the skin cancer. Those diagnosed one year before the survey and during the survey years were excluded from this study to reduce the bias from the impact of cancer diagnosis and treatment on physical and functional limitations and healthcare utilization.

The comorbidities were measured based on the number of self-reported medical conditions, such as heart disease, stroke, arthritis, chronic obstructive pulmonary disease (COPD), paralysis/amputation, bone disease, diabetes, hypertension, psychiatric disorder, and

neurological disease including Alzheimer's disease and dementia. These were recorded as yes/no on the questionnaires. Multiple chronic conditions were defined as having two or more of the above chronic conditions, including hypertension. This is similar to the other comorbidity measures, such as modified Charlson's Comorbidity Index in which hypertension is included (Romano, Roos, & Jollis, 1993).

Outcome measures

Healthcare utilization was measured using variables: rate of hospitalizations, re-hospitalizations, emergency department visits, and 30-day hospital readmissions based on Medicare claims. Specifically, Medicare inpatient claims were searched for hospitalization throughout all survey years to create a longitudinal history of hospitalization for each individual. Then the re-hospitalizations were counted since the first hospitalization during the study period. The duration between hospitalizations was assessed using admission and discharge dates on the claims. Similarly, the emergency department (ED) visits were identified using outpatient claims based on the type of services, facility codes, and detailed revenue codes. The duration between ED visits was assessed using claim admission and discharge dates as well. The total medical costs were summed from the Medicare reimbursed cost on the inpatient claims, outpatient claims, and physician claims (part B).

Statistical Analysis

We employed propensity score analysis method based on the potential outcome causal inference framework (Rubin, 2004) to obtain a correct estimates of average differences in the prevalence of physical limitations and functional limitations (ADL & IADL) and healthcare

utilization between cancer survivors and people without cancer. We first conducted a logistic regression using the baseline data with cancer status as the dependent variable, and age, race, gender, income level, all comorbidities, and their two-way interactions as independent variables. As suggested by DuGoff et al., the survey stratum and survey weight were also included as predictors in the logistic regression model, but the propensity score model was not weighted (DuGoff et al., 2014). The propensity score (P), i.e., the estimated probability of potentially having a cancer diagnosis for both cancer patients and people without cancer, was estimated from the logistic regression given below:

$$P = \frac{1}{(1 + e^{-(predicted\ log\ odds)})}$$

Then a new weight was calculated as the product of the original MCBS cross-sectional sampling weight and propensity score weight, where 1/P was for cancer survivors, and 1/(1-P) was for people with no history of cancer. This new weight deducted more on those participants who were in the tails of the propensity score distributions. Next, we multiplied the new weight with the average P for cancer patients or the average 1-P for people without cancer to correct the outliers in the new weights (also a form of stabilized weight) (Guo & Fraser, 2015). The final new weights were multiplied to the MCBS survey weight and then used for comparing physical and functional limitations between cancer survivors and those without cancer in all the analyses. The socio-demographic characteristics and comorbidities were assessed using weighted mean and standard error (SE) for continuous variables and weighted frequency along with percentage for categorical variables. The group comparisons were analyzed using appropriate t-test and Rao-Scott χ^2 tests.

Furthermore, we assessed potential confounding effect prior to the final outcome model specification using the Mantel-Haenszel stratification analysis. Multivariable logistic regression models incorporating the above calculated new weights and, adjusting for both socio-demographic characteristics and comorbidities, were used to estimate the independent effect of cancer status on physical and functional limitations at baseline. This approach is similar to the double robust method used in propensity score analysis. The adjusted logistic models were also used to estimate the average predicted marginal probabilities of having limitations in each year. Similar process was employed for examining the healthcare utilization. All analyses were performed in SAS 9.4 (SAS Institute, Inc., Cary, NC) using the new weights to account for the multi-stage survey design and the appropriate subpopulation (domain) analysis. SAS procedures for survey data such as PROC SURVEYFREQ, SURVEYMEANS, and SURVEYLOGISTIC were used in the analyses. A p-value of < 0.05 was used for statistical significance.

Results

Cancer survivors accounted for 19.3% of total MCBS participants in the study. The description of participants' socio-demographic characteristics, comorbidities of cancer survivors, and site of cancer by cancer status after weighting by propensity score are presented in Table 4.

Table 4: Demographic characteristics of older cancer survivors and those without cancer

Characteristics	Cancer survivors (weighted: 19.3%)	People without cancer (weighted: 80.6%)	P-value
Age (Mean, SE)	73.7 (0.2)	73.6 (0.1)	
65 to 74	59.2	60.4	
75 to 84	29.2	28.0	0.52
≥ 85	11.5	11.6	

Gender			
Male	41.7	44.3	0.20
Female	58.3	55.7	
Race/ethnicity			
Caucasian	86.7	86.6	
African American	7.6	8.0	0.89
Other	5.6	5.3	
Income (per year)			
<$15,000	20.6	20.8	
$15,000 to $30,000	31.0	30.9	0.98
≥ $30,000	48.3	48.3	
Multiple chronic conditions (>=2)			
Yes	67.4	68.2	0.65
No	32.5	31.8	
Comorbidities			
Heart Disease	41.8	40.5	0.56
Stroke	9.2	9.8	0.40
Hypertension	66.6	65.7	0.60
Arthritis	57.0	56.1	0.56
COPD	18.9	16.0	0.01
Paralysis/Amputation	3.2	3.4	0.80
Bone Disease	24.1	21.1	0.01
Diabetes	8.9	9.0	0.81
Neurological disease	11.3	10.7	0.46
Psychological disease	4.5	4.3	0.76
Site of Cancer			
Lung	4.5	N/A	
Breast	28.6	N/A	
Prostate	21.3	N/A	
Colon	10.8	N/A	
Kidney	3.0	N/A	
Physical limitations (≥2)	21.7	20.0	0.16
ADL limitations (≥2)	13.6	12.1	0.39
IADL limitations (≥2)	8.9	7.0	0.01

Note: Unweighted N = 23,695; Weighed N = 110,086,170
Cancer Survivors: Unweighted N = 4,370; Weighed N = 21,310,022
People without cancer: Unweighted N = 19,325; Weighed N = 88,776,148
Abbreviations: SE – Standard Error, COPD – Chronic Obstructive Pulmonary Disease, ADL - Activities of Daily Living, IADL – Instrumental Activities of Daily Living

There was no statistically significant difference among these factors between cancer and non-cancer participants after weighting. The weighted mean age of participants was 74 years, with about 58% females among cancer survivors. There were 87% Caucasians and almost 21% of participants had an income of <$15,000 per year. No statistically significant difference was seen in various comorbidities, except for COPD (p = 0.01) and bone disease (p = 0.01). Around 89% of cancer survivors had one or more comorbidity, 67% had two or more comorbidities, 42% had three or more comorbidities, and approximately 20% had four or more comorbidities. The prevalence of comorbidities differed by number of comorbidities and types of cancer. Cancer survivors with a history of prostate and breast cancer had higher prevalence of comorbidities (14.8%, p = 0.0007 and 32.75%, p = 0.07, respectively) (supplement tables).

Supplement Tables:

1.1: The prevalence of comorbidities differed by number of comorbidities and types of cancer.

Type of cancer	>=1 comorbidity		>=2 comorbidities		>=3 comorbidities		>=4 comorbidities	
	(%)	P-value	(%)	P-value	(%)	P-value	(%)	P-value
Renal	0.58	0.96	0.55	0.73	0.53	0.70	0.92	0.08
Colon	2.18	0.33	2.35	0.04	2.57	0.008	2.99	0.002*
Prostate	4.25	0.49	3.77	0.06	3.54	0.02	3.28	0.06
Breast	5.50	0.54	5.65	0.75	6.22	0.09	7.23	0.001*
Lung	0.96	0.01	1.06	0.008	1.49	<0.0001	1.62	0.0001*

*p<0.05

The prevalence for other types of cancers such as brain, ovary, uterus and stomach were very less therefore they were not included.

1.2: Prevalence by number of comorbidities among cancer survivors and non-cancer participants

Number of Comorbidities	Cancer Survivors (%)	Non-Cancer Survivors (%)	P-value
>=1 comorbidity	89.2	88.4	0.54
>=2 comorbidities	67.4	68.2	0.65
>=3 comorbidities	42.3	40.3	0.18
>=4 comorbidities	20.6	17.6	0.006*

*p<0.05

Although cancer survivors had slightly higher prevalence of physical and functional limitations at baseline than those without cancer (21.7% vs. 20% for PL, 13.6% vs. 12.1% for ADL, and 8.9% vs. 7.0% for IADL) after weighting (Table 4), these differences were not statistically significant except for IADL (p=0.01). Accordingly, when compared to people without cancer, cancer survivors were 20% more likely to have physical limitations (aOR = 1.20, 95% CI: 0.93 – 1.54) and IADL limitations (aOR = 1.20, CI: 0.81 – 1.75), but these were not statistically significant after adjusting for patient's socio-demographic characteristics and comorbidities (Table 5). On the other hand, older age was significantly associated with higher prevalence of physical limitations (aOR = 1.05, 95% CI: 1.04-1.06, p<0.0001), and functional limitations ADL (aOR=1.06, 95% CI:1.05 – 1.07, p<0.0001) and IADL (aOR =1.05, 95% CI: 1.04 – 1.07, p<0.0001). In addition, participants with higher income and females were less likely to have physical and functional limitations (ADL & IADL). Participants with two or more comorbidities were almost five times more likely to have physical limitations (aOR = 4.9, 95% CI: 4.15 - 5.76, p<0.0001), and almost three to four times more likely to have functional limitations – [ADL (aOR=4.2, 95% CI: 3.47 - 5.06, p<0.0001), and IADL (aOR=3.02, 95% CI: 2.29 – 3.94, p<0.0001)] compared to those without it.

Table 5: Adjusted odds ratios for the risk of having physical and functional limitations after propensity score weighting

Determinants	Adjusted Odds Ratio (95% Confidence Interval)		
	Physical Limitations	Functional Limitations	
		ADL	IADL
Cancer survivors vs. Non-cancer	1.20 (0.93 - 1.54)	1.1 (0.85 - 1.38)	1.20 (0.81- 1.75)
Age (per year)	1.05 (1.04 - 1.06)[a]	1.06 (1.05 - 1.07)[a]	1.05 (1.04 - 1.07)[a]
Female vs. male	0.73 (0.65 - 0.83)[a]	0.89 (0.79 - 1.00)	0.86 (0.73 - 1.00)
African American vs. Caucasian	1.13 (0.86 - 1.49)	1.07 (0.87 - 1.32)	1.32 (1.05 - 1.66)
Income			
(ref: <$15,000 per year)			
$15,000 - $30,000	0.58 (0.51 - 0.67)[a]	0.64 (0.54 - 0.74)[a]	0.64 (0.53 - 0.79)[a]
≥ $30,000	0.33 (0.30 - 0.38)[a]	0.42 (0.36 - 0.49)[a]	0.39 (0.32 - 0.47)[a]
Comorbidity [≥2 vs. <2]	4.9 (4.15 - 5.76)[a]	4.2 (3.47 - 5.06)[a]	3.0 (2.29 - 3.94)[a]
Type of Cancer (compared to non-cancer)			
Lung	1.38 (0.81 - 2.34)	1.68 (0.98 - 2.90)	1.54 (0.77 - 3.07)
Breast	0.88 (0.63 - 1.23)	0.89 (0.61 - 1.29)	1.12 (0.68 - 1.85)
Prostate	0.68 (0.46 - 1.00)[b]	0.77 (0.52 - 1.14)	0.96 (0.56 - 1.66)
Colon	1.11 (0.76 - 1.62)	1.06 (0.69 - 1.63)	1.33 (0.79 - 2.23)
Kidney	0.88 (0.42 - 1.88)	1.90 (0.90 - 4.02)	1.03 (0.43 - 2.49)

Abbreviations: OR = Odds Ratio, CI = Confidence Interval, ADL - Activities of Daily Living, IADL – Instrumental Activities of Daily Living
Models were adjusted for cancer status, age, race, sex, income, comorbidities and type of cancer
[a]$p<0.0001$; [b]$p<0.05$

Tables 6 shows the healthcare utilization of participants by cancer status and the presence of physical and functional limitations (ADL & IADL). Among those with physical limitations, older cancer survivors had slightly lower rates of hospitalizations, but had much higher rates of re-hospitalizations (49.6% vs. 44.3%), emergency department (ED) visits (21.8% vs. 17.0%), and frequent ED visits within 30 days of a prior ED visit (13.9% vs. 8.2%) compared to those without cancer. Similar results were found among cancer survivors with functional limitations. The average healthcare costs were also higher among cancer survivors compared to individuals with no history of cancer.

As hypothesized, physical limitations and functional limitations led to an increased healthcare utilization in both cancer survivors and in people without cancer (Table 6). For example, among cancer survivors, the rate of hospitalization for physical limitations was 29.2% whereas for those without physical limitations was 13.8%, the rate of re-hospitalization was 49.6% vs. 34.1%; and the rate of ED visits was 21.8% vs. 8.7% among cancer survivors with and without physical limitations. However, among both cancer survivors and non-cancer survivors, there was no statistically significant difference in the rates of readmission within 30 days of a prior hospitalization, having more than two ED visits, or ED visit within 30 days of a prior ED on comparing groups with and without physical or functional limitations.

Table 6: Healthcare utilization of older cancer survivors by physical & functional limitations after propensity score weighting

Health related outcomes	Having limitations		P-	Not having limitations		P-value
	Cancer survivors (%)	Non-cancer patients		Cancer survivors (%)	Non-cancer patients	
Physical limitations						
Rate of hospitalizations	29.2	32.7	0.16	13.8	11.8	0.03

Rate of re-hospitalization	49.6	44.3	0.11	34.1	34.8	0.85
Rate of hospital readmission within 30 days	13.2	14.5	0.36	11.7	13.8	0.11
Rate of Emergency Department	21.8	17.0	0.01	8.7	8.2	0.54
≥2 ED visits	27.9	23.6	0.23	24.0	22.1	0.55
ED visit within 30 days of prior ED visit	13.9	8.2	0.39	11.0	9.4	0.43
Average Medicare Cost ($) Per Hospitalization (Mean, SD)	22,971 (2,478.4)	20,068 (854.2)	--	15,600 (1,479.7)	17,173 (655.2)	--
ADL						
Rate of hospitalizations	32.1	33.6	0.66	14.8	13.4	0.09
Rate of re-hospitalization	50.5	45.2	0.19	36.7	36.4	0.94
Rate of hospital readmissions	14.9	14.6	0.83	11.3	13.9	0.02
Rate of Emergency Department (ED) Visits	25.8	17.4	0.001	9.3	8.9	0.58
≥2 ED visits	27.2	23.1	0.40	25.0	22.5	0.32
ED visit within 30 days of prior ED visit	9.8	8.0	0.62	13.2	9.3	0.02
Average Medicare Cost ($) Per Hospitalization (Mean, SD)	23,711 (2,689.2)	20,982 (1,170.1)	--	16,492 (1,462.5)	17,413 (560.1)	--
IADL						
Rate of hospitalizations	30.3	34.9	0.33	15.9	14.6	0.12
Rate of re-hospitalization	45.3	47.7	0.61	40.0	37.2	0.31
Rate of hospital readmissions within 30 days	12.6	15.1	0.26	12.3	13.8	0.13
Rate of Emergency Department	24.2	20.1	0.28	10.3	9.2	0.13
≥2 ED visits	21.6	26.4	0.30	26.5	22.0	0.11
ED visit within 30 days of prior ED	5.0	8.1	0.29	13.7	9.1	0.01
Average Medicare Cost ($) Per Hospitalization (Mean, SD)	24,916 (3,877.1)	22,699 (1,533.4)	--	17,101 (1,326.5)	17,579 (537.5)	--

SD: Standard Deviation, ADL - Activities of Daily Living, IADL – Instrumental Activities of Daily Living

Table 7 provides adjusted odds ratios for the above comparisons. For example, among those with PL, cancer survivors were 32% more likely to be re-hospitalized (aOR: 1.32, 95% CI: 0.96 – 1.82, p>0.05) and 72% more likely to visit the ED (aOR: 1.72, 95% CI: 1.26 – 2.35, p<0.05). Similarly, cancer survivors with ADL were almost three times more likely to have frequent ED visits (aOR:2.68, 95% CI: 1.86 – 3.86, p<0.001). Similar findings were noted among those with IADL.

Table 7: Adjusted Odds Ratio for healthcare utilization by cancer status and by physical and functional limitations status

Determinants	Adjusted OR for cancer survivors vs. non-cancer patients (95% CI)		
	Physical Limitations	Functional Limitations	
		ADL	IADL
Having limitations			
Rate of hospitalizations	0.81 (0.58 – 1.11)	0.72 (0.48 – 1.09)	0.59 (0.35 – 0.98)
Rate of re-hospitalization	1.32 (0.96 – 1.82) [b]	1.35 (0.92 – 1.96)	1.08 (0.58 – 2.00)
Rate of hospital readmissions within 30 days	1.00 (0.77 – 1.30)	1.05 (0.77 – 1.45)	0.67 (0.36 – 1.25)
Rate of Emergency Department (ED) Visits	1.72 (1.26 – 2.35)[b]	2.68 (1.86 – 3.86)[a]	2.29 (1.27-4.13)[b]
≥2 ED visits	1.09 (0.71 – 1.67)	1.10 (0.66 – 1.83)	0.98 (0.51 – 1.89)
ED visit within 30 days of prior ED visit	1.43 (0.74 – 2.74)	0.93 (0.37 – 2.30)	1.36 (0.47 – 3.89)
Having no limitations			
Rate of hospitalizations	1.19 (0.89 – 1.60)	1.19 (0.92 – 1.54)	1.16 (0.92 – 1.46)
Rate of re-hospitalization	1.23 (0.84 – 1.82)	0.91 (0.64 – 1.28)	0.98 (0.73 – 1.33)
Rate of hospital readmissions within 30 days	1.07 (0.75 – 1.54)	0.95 (0.68 – 1.33)	1.01 (0.77 – 1.32)
Rate of Emergency Department (ED) Visits	1.32 (0.99-1.74)[b]	1.21 (0.94 – 1.56)	1.35 (1.10 – 1.65)[b]

≥2 ED visits	0.97 (0.56 – 1.70)	1.04 (0.67 – 1.63)	1.08 (0.73 – 1.61)
ED visit within 30 days of prior ED visit	1.40 (0.73 – 2.67)	1.72 (1.01 – 2.94)[b]	1.55 (0.94 – 2.55)

Abbreviations: OR = Odds Ratio, CI = Confidence Interval,
ADL - Activities of Daily Living, IADL – Instrumental Activities of Daily Living
Models were adjusted for cancer status, age, race, sex, income, comorbidities and type of cancer
[a]p<0.0001; [b]p<0.05

Discussion

There was no significant difference in the prevalence of physical and functional limitations between older cancer survivors and those without cancer after weighted by propensity score of cancer status, and also after adjusting for age, socio-demographic characteristics, and comorbidities. There was also no difference in the rates of hospitalization between them. However, cancer survivors were more likely to be re-hospitalized and visit emergency departments than those without cancer, particularly if they had either physical limitations or functional limitations (ADL & IADL). Physical and functional limitations exert a considerate burden on cancer survivors due to decreased ability to perform their daily tasks of living (León-Muñoz et al., 2007).

Our results are consistent with previous studies that have examined the factors associated with healthcare utilization and healthcare costs in older adults with functional limitations (Fernández-Olano et al., 2006; Heinrich et al., 2008). After carefully considering the propensity of having a cancer diagnosis, our study demonstrated that irrespective of cancer status, physical and functional limitations led to increased healthcare utilization among older individuals. Bhattacharjee et al. also demonstrated that when compared to functional independence, functional disability in older individuals was associated with increased healthcare utilization (Bhattacharjee, Gharabei, Kamal, & Riaz, 2017).

In our study, cancer survivors with physical and functional limitations had higher utilization of healthcare services and required more re-hospitalizations, ED visits, and ED visits within 30 days of a prior ED visit. Cancer survivors also had more comorbidities when compared to participants without history of cancer, which may result in increased visits to primary care physicians and specialists. The increased healthcare utilization can be reduced if these individuals received better coordinated care and counselling on preventive measures of physical and functional limitations during their regular physician visits (Chavan, Kedia, & Yu, 2017). The 2005 Institute of Medicine (IOM) report emphasizes the absence of guidance for best practices in cancer survivorship care which causes wide variations in care for these survivors (Jacobs & Shulman, 2017). A multi-disciplinary care infrastructure along with a cross-cutting model of care applicable to all practice settings is required for high quality cancer survivorship care. (Mayer, DK, Nasso, & Earp, 2017; McCabe et al., 2013). The survivorship shared care model in concordance with the Institute of Medicine standards should be implemented by advanced practitioners to provide better survivorship care to older cancer survivors (Thom et al., 2019). Shared care models with unified and holistic clinical approach may help curb the excess healthcare utilization among cancer survivors (Levit, Balogh, Nass, & Ganz, 2013).

Our study also found that the average Medicare cost per hospitalization was higher among older cancer survivors with physical or functional limitations compared to those without these limitations. The burden of healthcare expenditure was also found to be high among non-elderly cancer survivors with high out of pocket expenses (GuyJr et al., 2015). A recent year study by Choi & DiNitto showed that older adults with functional limitations were more worried about increased healthcare expenditure due to higher ED visits, among other factors (Choi &

DiNitto, 2018). Similar trends of healthcare utilization were reported in other studies as well (Becker et al., 2012; Brown, ML & Yabroff, 2006; Brown, M. L. et al., 2002; Lang et al., 2009; Riley et al., 1995). Physical and functional limitations among older cancer survivors led to significantly higher rates of frequent ED visits, compared to those without cancer.

In addition, the higher use of healthcare among older cancer survivors may hide the variation of cost by cancer stage. For example, some older patients with early stage cancer may have less healthcare expenditure, whereas patients with late stage of cancer diagnosis may incur significantly higher cost of care due to expensive chemotherapy and radiation therapy. Cost related to care is a major factor in assessing healthcare expense among these survivors as many of them forgo medical care due to unaffordable cost of care (Kent et al., 2013). However, our administrative data were not able to discern this information.

Our study has demonstrated a stronger impact of physical and functional limitations on the healthcare utilization of older cancer survivors, supporting its public health relevance. The results from our study can be used to tailor specialized plans for cancer survivors and address their healthcare needs post-cancer diagnosis and treatment. Healthcare providers need to understand the unique challenges faced by older cancer survivors in their daily lives and develop a better cancer survivorship plan which can deliver optimal quality care to these survivors. Early identification of rehabilitation goals on multidisciplinary level and effective planning for palliative care can help improve the functional status of older cancer survivors. As mentioned earlier, a well-integrated shared care model and multidisciplinary care provider system needs to be in place for more effective and efficient management of cancer survivors (Bazzell, Spurlock,

& McBride, 2015). Cost conscious and clinically effective care for these patients may enhance their overall health status and reduce the burden on the healthcare system.

Strengths and Limitations

One of the main strengths of our study is that MCBS is a national survey representative of the entire older Medicare beneficiary population in the United States. A complete profile of physical and functional limitations experienced by older Medicare population and cancer survivors was obtained through the MCBS data for this study. Another strength of our study is that it is a longitudinal study in which we used follow-up data to determine the impact of functional limitations on healthcare utilization during the entire study period. Most importantly, we analyzed the data based on the causal inference theory which strengthens our interpretation. We used the propensity score method to account for key confounders and ensure the comparability between cancer survivors and those without any history of cancer, thus avoiding over- or under-estimation of the differences in healthcare utilizations between cancer survivors and those without cancer.

The study also has a few limitations. The MCBS questionnaires only contains self-reported information which may lead to recall bias. For those who were diagnosed with cancer more than 1 year prior to the survey, there is no information about the age of cancer diagnosis, therefore, we were not able to identify the length of cancer diagnosis for these patients. There was also no information on the stages of cancer and severity of diseases, therefore variation in healthcare cost by different stages of cancer could not be assessed. In addition, we did not include MCBS participants <65 years of age in our analysis, as their eligibility of Medicare coverage is mainly due to disability or end stage

renal disease. Therefore, our results are not generalizable to all cancer survivors. We dichotomized the physical and functional limitations because the distribution of the original score was skewed to the left which may reduce the granularity of the measure.

Furthermore, the healthcare utilization of older individuals may differ based on the number of comorbidities, history of cancer diagnosis, and type of treatment received for it. In our study, we adjusted for these variables but did not conduct separate analyses by these factors since they may mask the variations in healthcare utilization among older adults. In addition, propensity score analysis does not account for unmeasured confounders, so the estimates may still be biased. Also, due to the release cycle of MCBS data, the initial data presented in this study is 8 years old. In recent times, improved care plans may be available for these survivors to mitigate some of the issues. However, there is a need to identify and manage them in a more coordinated manner, which, in turn, will reduce the burden on healthcare in the long run.

Conclusion

As the older adult population continues to grow, we need to devise better care plans for these individuals to avoid excess healthcare expenditure, especially among the older cancer survivors, which is a rapidly growing population in the U.S. Since higher prevalence of physical and functional limitations can lead to increased utilization of healthcare services, coordinated care among primary care physicians, geriatricians, oncologists, and other specialists will be the key to improve the standard of healthcare among the cancer survivor population. Attending primary care physicians can play a critical role in incorporating assessment of physical and functional status and provide advice on preventive measures to older cancer survivors to improve their overall health and reduce costs associated with excessive healthcare utilizations.

CHAPTER 4

IMPACT OF SELF-ASSESSED HEALTH STATUS AND PHYSICAL AND FUNCTIONAL LIMITATIONS ON HEALTHCARE UTILIZATION AND MORTALITY AMONG OLDER CANCER SURVIVORS

Abstract:

Purpose: This purpose of this study was to examine the impact of physical limitations, functional limitations and self-assessed health status on mortality and healthcare utilization among older cancer survivors.

Method: National Medicare Current Beneficiary Survey (MCBS) data from 2005-2013 were used for analysis. Physical limitations, Activities of Daily Living (ADL) Instrumental Activities of Daily Living (IADL) were assessed on multiple questions, and self-assessed health was measured on a five-point scale (1-5: Excellent -Poor). Logistic regression model and Poisson regression models were developed for hospitalization, re-hospitalization and mortality rates based on three follow up years.

Results: Cancer survivors with poor self-assessed health had higher rate of hospitalizations (aOR:1.60, 95% C.I.: 1.47 – 1.72, $p<0.001$) compared to non-cancer participants. Compared to participants with no history of cancer, cancer survivors with IADL (RR: 1.41, 95% C.I.: 1.25 – 1.58, $p<0.001$) and poor self-assessed health (RR: 1.39, 95% C.I.:1.21-1.60, $p<0.05$) were more likely to have higher number of hospital readmissions within 30 days of a prior hospitalization. Three-year mortality rate was significantly higher among cancer survivors with poor self-assessed health (Hazard Ratio: 2.81, $p<0.001$).

Conclusion: Physical and functional limitations significantly impact self-assessed health among cancer survivors. Health care providers should incorporate formal assessments of functional status among older patients in their clinical practice.

Implication for Cancer Survivors: Self-reported health status is a valuable and independent predictor of mortality among cancer survivors.

Introduction

Cancer is rapidly changing from a life threatening condition into a chronic disease (Mols et al., 2005), and the life expectancy of people with cancer has improved significantly over the years owing to early detection of cancer, use of advanced technologies, newer treatments, and improved cancer follow up care (Gotay & Muraoka, 1998; Sweeney et al., 2006). Although the increased life expectancy among cancer patients is a major achievement, an equal challenge is to keep this population healthy. Older cancer survivors account for almost two thirds of cancer survivor population (de Moor et al., 2013). These survivors often not only receive less optimal treatment options such as incomplete doses and treatment cycles, but also suffer from prolonged side effects of cancer treatment, which may deteriorate their overall mobility and physical functioning, resulting in worsening of their health (Becker et al., 2012).

Self-assessed health status is a widely-used yet poorly understood health measure to compare and evaluate the health status of individuals (Jylha, 2009). In the past decade increasing evidence has emerged about the predictability of people's self-rated health and their length of survival (Berger, Heyden, & Oyen, 2015; Jylha, 2009). In addition to being an independent predictor of survival, self-assessed health status was strongly associated with the ability of older

cancer survivors to independently manage their daily lives and was also found to be an independent predictor of functional decline in older adults (Wolinsky et al., 2011).

The two key components that affect health are physical and functional limitations (Parker et al., 2003). Physical limitations refer to difficulty in performing basic physical activities such as walking, lifting, stooping, sitting, and so on (Stineman, Margaret G. et al., 2014); whereas functional limitations refer to the inability of an individual to perform essential tasks of daily living. Functional limitations include Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) (Katz, 1983; Lawton & Brody, 1970). ADL includes activities such as using toilet, dressing, bathing, eating, walking around the house, while IADL include social activities like shopping, managing bills and participating in events of social life (Stewart et al., 1977; Field & Jette, 2007).

On the other hand, how self-assessed health is related to functional limitations and how they impact health care utilization and mortality among older cancer survivors has not been documented systematically in the literature. Although the term "self-assessed health" is operationalized in a variety of ways in many studies, it remains a vague and subjective value judgement. Many factors such as race, gender, age, education, medical conditions and psychological adaptations can affect self-perception of health (Franks, Gold, & Fiscella, 2003). Conceivably, self-assessed health will be highly correlated with physical and functional limitations. However, it is well-known that self-assessed health status tends to be misreported (Latkin, Edwards, Davey-Rothwell, & Tobin, 2017; Vaillant & Wolff, 2012). For example, responders may report favorable answers to please the interviewer, avoid embarrassment of unfavorable answers, and conform to cultural norms (social desirability bias) (Vaillant & Wolff, 2012). Thus, these sets of measures may have different implications in terms of outcomes.

Older cancer survivors tend to have higher health care use, such as emergency department visits, than non-cancer people (Kedia, Chavan, Boop, & Yu, 2017). Beyond the well-studied impact of socio-economic factors on health and health care use (Alam, 2006; Saeed, Oduro, Ebenezer, & Zhao, 2012), and of self-assessed health status on mortality and other clinical outcomes in older adults (Lee, Y., 2000; Shadbolt et al., 2002), there is a paucity of studies examining the impact of functional limitations and self-assessed health status on mortality and healthcare use among older cancer survivors. Understanding the intricate relationship between self-assessed health status, physical limitations and functional limitations, and its impact on health care utilization allows the health care providers to make well-informed decisions and optimally deliver health care to older cancer survivors. In this study, we hypothesized that self-assessed health status, and physical and functional limitations, would have independent effects on predicting mortality and health care use among older cancer survivors.

Method

Study Sample. Medicare Current Beneficiary Survey (MCBS) data from 2005 to 2013 is used in this study. MCBS is a nationally representative longitudinal, multi-stage survey administered by the Centers for Medicare and Medicaid Services (CMS). It represents the health and healthcare experience of the entire Medicare beneficiaries. The MCBS conducts three interviews each year over a period of four years to track changes in health status and health care use among all Medicare beneficiaries. In each Fall round of the year, one third of survey participants are rotated out and replaced by an equivalent number of new participants. In the first interview, baseline information is collected on demographics, medical history, general health status and healthcare use. During the fourth interview year, information from previous years is

verified; therefore, longitudinal data is available for three consecutive years. Various outcomes are assessed for each respondent, such as self-assessed health status and history of cancer diagnosis, but functional status is assessed only at the baseline survey and in the first two years of follow-up. These data are linked to Medicare claims file for the entire follow up period. Sampling weights are also provided for analytical purposes which account for the complex sampling design and non-response rate of the surveys (Medicare current beneficiary survey (MCBS).2016).

In this study, we used information on sociodemographic characteristics, health status, and information collected on physical and functional limitations during each Fall round of the survey year. Information collected in other rounds mainly focuses on access to health care and health care use during the year, which was also used in this study. We restricted our study cohort to participants aged 65 or older (n = 17,751 at baseline) and excluded participants who were diagnosed with cancer within one year prior to the baseline survey or those who developed new cancer during the study period (n=821), and those who died during the first six months since the enrollment into the MCBS (n=1,323) because their health needs, disabilities and health care utilizations differ significantly from the rest of the cohort. We did not include participants <65 years of age in our analysis, as their eligibility of Medicare coverage is mainly due to disability or end stage renal disease. In the final cohort, we included only those participants who had at least one follow up interview during the study period. Thus, some participants had three visits while others had only two. Participants with missing values for functional limitations were also excluded from the final cohort (n = 99). The final sample consisted of 17,751 participants, representing a weighted total of 61,695,226 older Medicare beneficiaries.

Measuring self-assessed health and physical and functional limitations

The survey questions relating to self-assessed health (Q: How is your general health compared to others of same age) were measured on a five-point Likert scale as 1 = Excellent, 2 = Very Good, 3 = Good, 4 = Fair and 5 = Poor. The distribution of responses therefore, we dichotomized the five-point scale into a binary variable with 1 = Good health (includes 1, 2, 3 of self-assessed health measure) and 2 = Poor health (includes 4 and 5 of self-assessed health measure) thus producing a binary measure of the outcome for self-assessed health.

The MCBS measures self- reported limitations in three domains: physical, ADL, and IADL. Each domain includes five or six items measured on a five-point scale (1 = no difficulty, 2 = a little difficulty, 3 = some difficulty, 4 = a lot of difficulty, 5 = unable to do it). Physical limitations include difficulty in stooping/crouching/kneeling, walking ¼ miles, reaching/extending arms above shoulder, lifting/carrying 10 lbs., and writing/handling objects. ADL limitations include difficulty in bathing, dressing, walking in the house, eating, getting in and out of chair or bed, and using toilet. IADL limitations include difficulty in using telephone, shopping, doing light housework, preparing meals, and paying bills. The distribution of score for responses to each limitation item skewed heavily to the right. Therefore, we first dichotomized the responses to each item, where "a lot of difficulty" or "unable to do it" responses were considered as having a limitation. Next, participants who have two or more (out of a total five or six) limitations were considered as having an overall physical or functional limitation.

Similar to Stineman et.al., we further created variables for stages of functional limitations (ADL & IADL) from stage 0 (no limitations) to stage IV (severe limitations)

(Stineman, Margaret G. et al., 2014). Stage I of ADL limitations included difficulty in walking and/or difficulty getting in and out of bed or chair. Stage 2 included difficulty in bathing, dressing in addition to Stage I limitations. Stage III included difficulty in eating, using toilet, bathing, but not all ADLs and stage IV included all ADL limitations. Similarly, we created IADL stages of limitations, where Stage I included problem doing heavy housework and/or problem shopping. Stage II included problem doing light and heavy housework, problem shopping, problem preparing meals. Stage III included IADL limitations such as difficulty using telephone, managing money but not all IADLs and stage IV included all IADL limitations.

Measuring socio-demographic characteristics

MCBS collects information on socio-demographic characteristics and general health status during the face-to-face interviews. Socio-demographic characteristics include age at baseline survey (also regrouped as 65-74, 75-84 and 85 or older), gender, income (<$15,000, $15,000 - $30,000 and ≥$30,000), and race/ethnicity (regrouped as Caucasian, African-American and Other). Consistent with the definition adopted by the National Cancer Institute, we defined cancer survivors as those having survived cancer for at least one year after cancer diagnosis (National cancer institute.2015). This definition excludes those cancer patients who are still receiving cancer treatment (likely within the first year). Their health status and health care utilizations have a different pattern from other patients. History of cancer diagnosis was assessed in questions such as "ever told having a non-skin cancer", "had a cancer past year" and site (body part/organ) of cancer. Those with history of non-melanoma skin cancer were not considered cancer survivors for the purpose of analysis because of the non-invasiveness of skin cancer.

The number of comorbidities is based on the number of self-reported medical conditions such as a heart disease, a stroke, arthritis, chronic obstructive pulmonary disease (COPD), paralysis/amputation, a bone disease, diabetes, hypertension, a psychiatric disorder, or a neurological disease including Alzheimer's disease and dementia. These were recorded as yes/no on the questionnaires. Multiple chronic conditions are defined as having two or more of the above chronic conditions. This is similar to other comorbidity measures such as Charlson's Comorbidity Index using ICD-9 (Romano et al., 1993).

Healthcare utilization was measured as rates of hospitalizations, hospital readmissions, emergency department visits and 30-day hospital readmissions based on Medicare claims. Medicare inpatient claims were specifically searched for hospitalizations throughout the survey duration and the first (index) hospitalization was identified for each participant. Subsequent admissions were then counted beginning from the index hospitalization during the study period. The duration between hospitalizations was assessed using admission dates and discharge dates on the medical claims. Similarly, emergency department (ED) visits were identified using outpatient claims based on the type of services, facility codes, and detailed revenue codes. The duration between ED visits was assessed using claim admission date and discharge dates as well. The total medical costs were summed from the Medicare reimbursed cost on the inpatient claims, outpatient claims, and physician claims (part B). Health care utilizations in the first follow up year were used in the analysis.

Statistical Analysis

Baseline socio-demographic characteristics and comorbidities among older cancer survivors were assessed using weighted mean and standard error (SE) for continuous variables and weighted frequency and percentage for categorical variables, which were compared between those who reported fair or poor health and those with good to excellent health by student t test and Rao-Scott χ^2 test, respectively. The relationship between self-assessed health and presence of and stages of physical and functional limitations was assessed using Cochran-Mantel-Haenszel χ^2 test. Multivariable regression models were used to estimate the effects of baseline physical and functional limitations, and self-assessed health on health care utilizations in the first follow up year, adjusted for socio-demographic characteristics and comorbidities. Multivariable Logistic regression was used for binary outcomes (e.g., ever had hospitalization, emergency department visit) and Poisson regression was used for count variables (e.g., the number of hospitalizations, re-hospitalizations, number of emergency department visits). Survival analysis with hazard model was used to predict mortality, defined as death during the three years of follow up.

All analyses were performed in SAS 9.4 using the survey weights based on the multi-stage survey design and the appropriate subpopulation (domain) analysis was conducted to obtain results at baseline and during the first follow up. Statistical significance was assessed using a two-sided test with a significance of $p < 0.05$. SAS procedures such as Proc Surveyfreq, Surveymeans and Surveylogistic were used for analysis. (SAS Inc., Cary, NC).

Results

Of all older cancer survivors, 18.63% reported having fair or poor health. Table 8 describes the demographic characteristics of MCBS participants as well as the comorbidities and types of cancer. Apart from gender, there are statistically significant differences in baseline demographic characteristics of participants between the two groups (poor-fair vs. good-excellent health status, $p<0.0001$). The mean age of cancer survivors was 75 years with more older people reporting fair or poor health. Most participants were Caucasians with an income of <$30,000 per year. Cancer survivors who reported their general health status as fair or poor had higher prevalence of multiple comorbidities compared to those who reported their general health status as excellent, very good or good (77.85% vs. 49.60%, $p<0.0001$). No statistically significant differences were seen in types of cancer except for uterine and colon cancers ($p <0.05$).

Table 8: Demographic Characteristics of participants based on self-assessed health status

Characteristics	General Health Status (Excellent, Very Good, Good) Weighed: 81.36%, N = 14,212 (%)	General Health Status (Fair, Poor) Weighed:18.63%, N = 3,503 (%)	*P*-value
Age (year, mean, SE)	75.08 (0.08)	75.59 (0.14)	
65 to 74	52.88	48.26	
75 to 84	34.50	38.42	<0.001
≥ 85	12.61	13.31	
Gender			
Male	43.72	42.68	
Female	56.27	57.32	0.30
Race/ethnicity			
Caucasian	89.31	81.61	<0.001
African American	6.69	11.21	
Other	3.98	7.17	
Income (per year)			
<$15,000	18.87	38.03	
$15,000 to $30,000	30.87	33.07	<0.001
≥ $30,000	50.25	28.89	
Comorbidities			

Heart Disease	38.92	60.59	<0.001
Stroke	8.65	19.61	<0.001
Arthritis	55.96	73.68	<0.001
COPD	13.43	30.86	<0.001
Paralysis/Amputation	2.86	6.88	<0.001
Bone Disease	21.50	29.62	<0.001
Diabetes	9.81	18.52	<0.001
Hypertension	63.28	78.46	<0.001
Neurological disease	2.67	7.66	<0.001
Psychological disease	8.36	17.30	<0.001
Multiple chronic conditions (>=2)	49.60	77.85	<0.001
Types of Cancer			
Breast	5.12	5.52	0.35
Prostate	4.56	5.01	0.29
Colon	2.24	3.08	0.002
Bladder	0.89	1.25	0.06
Uterine	1.30	2.09	0.001

Table 9 demonstrates the general health status of cancer survivors by physical and functional limitations. Cancer survivors with fair or poor general health status had more physical (57.40% vs. 15.02%), ADL (37.16% vs. 9.04%) and IADL (44.91% vs. 10.73%) limitations compared to those reporting good to excellent health. The differences between the two groups were statistically significant ($p<0.0001$). Similar results were seen based on the stage of limitations. The appendix table I shows the median estimate for each item of physical and functional limitations by self-assessed health and presents a consistent picture as in Table 9.

Table 9: General Health Status in Older Medicare Beneficiaries with Physical Limitations and Functional Limitations (ADL & IADL)

Functional Limitations	General Health Status (Excellent, Very Good, Good) (weighted %)	General Health Status (Poor, Fair) (weighted %)	P-value χ^2
Two or more physical limitations			
Yes	15.02	57.40	

No	84.97	42.59	<0.0001
Two or more ADL limitations			
Yes	9.04	37.16	
No	90.95	62.83	<0.0001
Stages of ADL			
Stage 0	79.80	41.37	
Stage I	12.22	27.15	
Stage II	4.37	15.20	<0.0001
Stage III	3.20	13.05	
Stage IV	0.39	3.21	
Two or more IADL limitations			
Yes	10.73	44.91	
No	89.26	55.08	<0.0001
Stages of IADL			
Stage 0	73.48	31.00	
Stage I	14.46	26.85	
Stage II	4.06	18.47	
Stage III	6.98	16.94	<0.0001
Stage IV	1.00	6.72	

The self-assessed fair or poor health status and presence of physical and functional limitations in participants independently increased the overall healthcare use. Table 10 presents the risk ratios by self-assessed health status to physical and functional limitations in cancer survivors based on multivariable models. The number of hospitalizations were 21% higher in those with fair or poor health (RR, 1.21 95% CI, 1.14- 1.28; $p< 0.05$) compared with those reported good to excellent health, and 13% higher in those with physical limitations (RR, 1.13; 95% CI, 1.07 – 1.19; $p<0.001$), 7% higher for ADL (RR, 1.07; 95% CI, 1.01-1.13; $p<0.05$) and 15% higher for IADL (RR, 1.14; 95% CI, 1.09-1.21; $p<0.001$) compared with those without limitations. Similarly, the number of hospital readmission within 30 days was 41% higher among those with ADL

(RR, 1.41; 95% CI,1.25–1.58; p<0.001) and 39% among those who reported fair or poor health (RR, 1.39; 95% CI, 1.21–1.60; p<0.05). Participants with fair or poor self-assessed health also had increased number of re-visits to the emergency room (RR, 1.22; 95% CI, 1.07 – 1.39, p<0.05). Similarly, the rate of hospitalization was higher among those with physical limitations (OR, 1.40; 95% CI, 1.30 –1.50, p<0.001), poor self-assessed health (OR, 1.60; 95% CI, 1.47–1.72, p<0.001) and worst health compared to last year (OR, 1.56; 95% CI, 1.46–1.65, p<0.0001). Furthermore, cancer survivors who reported poor self-assessed health were at higher risk of mortality (Hazard ratio, 2.81; 95% CI, 2.81-2.82, p<0.001) than those reporting good to excellent health.

Similar findings exist when functional limitations were estimated by stages of limitations (ADL & IADL) (Table 11). Those with stage IV ADL limitations had higher healthcare utilization whereas those with stage II of IADL limitation were two times more likely to have hospitalizations (aOR, 2.20; 95% CI, 1.98 – 2.41, p<0.001) and rehospitalizations (aOR, 1.87; 95% CI, 1.63 – 2.14, p<0.001). This implies that cancer survivors who had difficulty doing light housework and heavy housework or had difficulty shopping or preparing meals incurred more healthcare use than those in later stages of limitations.

Table 10: Multivariable adjusted association of self-assessed health status, physical limitations, and functional limitations with healthcare utilization and all-cause mortality

Outcome variables	Physical Limitation	ADL	IADL	Self-Assessed Health (Poor or fair vs. good or excellent)
Mortality (HR)	1.00 (1.00-1.01) [a]	1.11 (1.11-1.11) [a]	1.01(1.01-1.01) [a]	2.81(2.81-2.82) [a]
Number of hospitalizations	1.13 (1.07 – 1.19) [a]	1.07 (1.01 – 1.13) [b]	1.15 (1.09 – 1.21) [a]	1.21 (1.14 – 1.28) [b]
Rate of Hospitalization	1.40 (1.30 – 1.50) [a]	1.19 (1.10 – 1.30) [a]	1.41 (1.28 – 1.54) [a]	1.60 (1.47 – 1.72) [a]
Rate of re-hospitalization	1.22 (1.10 – 1.35) [a]	1.06 (0.95 – 1.18)	1.28 (1.18 – 1.40) [a]	1.39 (1.24 – 1.55) [a]
Among Hospitalization				
Number of hospital readmissions within 30 days	1.14 (1.00 – 1.29) [b]	1.15 (0.99 – 1.33) [b]	1.41 (1.25 – 1.58) [a]	1.39 (1.21 – 1.60) [b]
Rate of 30-day hospital readmission	1.05 (0.91 – 1.21)	1.16 (1.02 – 1.32) [b]	1.16 (1.02 – 1.31) [b]	1.23 (1.07 – 1.40) [b]
Number of Emergency room visits	1.03 (0.98 – 1.07)	1.02 (0.97 – 1.08)	1.07 (1.02 – 1.12) [b]	1.09 (1.05 – 1.13) [a]
Number of revisits to Emergency room	1.06 (0.92 – 1.22)	1.10 (0.92 – 1.30)	1.11 (0.93 – 1.32)	1.22 (1.07 – 1.39) [b]
Rate of >=3 emergency room visit	1.06 (0.90 – 1.24)	1.16 (0.92 – 1.46)	1.12 (0.91 – 1.40)	1.29 (1.09 – 1.52) [b]

Note: ADL - Activities of Daily Living; IADL – Instrumental Activities of Daily Living
HR = hazard ratio; [a] $p<0.001$, [b] $p<0.05$,
Models were adjusted for age, race, sex, income, comorbidities, and types of cancer,
Logistic regression was used for rate of hospitalization, and Poisson regression for number of hospitalizations.

Table 11: Adjusted odds ratio for healthcare utilization by stages of functional limitations (ADL & IADL)

	Rate of hospitalization	Rate of Rehospitalization	Rate of 30 days hospital readmission	Rate of ≥3 ED visits
ADL limitation				
Stage I	1.34 (1.24 – 1.44) [a]	1.05 (0.94 – 1.17)	0.92 (0.81 – 1.06)	1.16 (0.92 – 1.45)
Stage II	1.67 (1.53 – 1.83) [a]	1.27 (1.11 – 1.44) [b]	1.18 (1.00 – 1.39) [b]	1.20 (0.96 – 1.50)
Stage III	1.80 (1.62 – 2.00) [a]	1.30 (1.12 – 1.51) [b]	1.19 (0.99 – 1.43)	1.09 (0.79 – 1.52)
Stage IV	2.50 (1.97 – 3.18) [a]	1.64 (1.19 – 2.25) [b]	1.49 (1.07 – 2.07) [b]	1.67 (0.87 – 3.20)
IADL limitation				
Stage I	1.75 (1.62 – 1.90) [a]	1.52 (1.33 – 1.73) [a]	1.34 (1.11 – 1.61) [b]	1.16 (0.88 – 1.53)

Stage II	2.2 (1.98 – 2.41) [a]	1.87 (1.63 – 2.14) [a]	1.53 (1.28 – 1.83) [a]	1.29 (0.94 – 1.76)
Stage III	1.76 (1.60 – 1.96) [a]	1.69 (1.50 – 1.91) [a]	1.50 (1.26 – 1.77) [a]	1.51 (1.16 – 1.94) [b]
Stage IV	1.90 (1.61 – 2.24) [a]	1.44 (1.16 – 1.79) [b]	1.09 (0.82 – 1.45)	1.07 (0.66 – 1.74)

Note: Models were adjusted for age, race, sex, income and comorbidities. All comparisons are against stage 0

[a] $p<0.0001$, [b] $p<0.05$

Discussion

Self-assessed health status is highly correlated with physical and functional limitations in this population of older cancer survivors. Despite the possibility of inflated response (Vaillant & Wolff, 2012) to measurement of self-assessed health, it is also a strong independent predictor of mortality and health care utilization. In addition, physical and functional limitations have a significant impact on healthcare utilization and mortality among older cancer survivors, independent of self-assessed health.

The findings of this study are comparable to prior studies which showed self-rated health as a useful measure of the objective health status of older adults, also an important predictor of survival in them (Husain & Ghosh, 2011; Idler, Russell, & Davis, 2000; Lee, Y., 2000). Our results provide additional evidence that self -assessed health is a strong predictor of mortality among older cancer survivors. Poor self-assessed health and presence of physical and functional limitations have also been shown to result in higher healthcare utilization (DeSalvo, Fan, McDonell, & Fihn, 2005; Schousboe et al., 2019). Our results agree with recent studies that showed that comorbidities increase healthcare use among cancer survivors (Jones, Chennupati, Nguyen, Fedorenko, & Ramsey, 2019; Kedia et al., 2017). This can be reduced by better counselling on preventive measures and

adequate assessment of functional health status during routine check-up visits (Chavan et al., 2017).

Evaluation of self-assessed health, including self-reported health status compared to a year ago, is a vague and subjective measure. In addition to responder's socio-economic characteristics and medical conditions, social desirability bias during interview process and psychological adaptation to health conditions are two of the most important factors that affect the score of self-assessed health (Krumpal, 2013). It has been shown that responders tend to misreport their health as good or very good regardless of their actual health status (Vaillant & Wolff, 2012). This may lead to a positive shift of the actual health status. Furthermore, people may get used to their current health status, despite the existence of many medical conditions. Therefore, measuring functional status such as physical and functional limitations is important to assess the actual health status of these individuals. Our findings suggest that primary care physicians should include the assessment of both general health and functional limitations in their routine check-up and develop individualized care plans for older cancer survivors along with caregivers. The stages of functional limitations can be used to assess the functional status among these survivors.

Our study also emphasizes the need to adopt an all-inclusive care model. We found that those with physical and functional limitations and fair or poor self-assessed health had significantly higher health care utilizations. Research evidence suggest that the use of shared care models can be beneficial in addressing the additional healthcare needs of older population (McCabe et al., 2013). The results from this study underline the need to establish customized shared care models with multidisciplinary care infrastructure

capable of addressing the healthcare needs of older cancer survivors. Healthcare providers need to understand the unique challenges faced by older cancer survivors for self-management of daily activities. A clinically efficient and effective care for these survivors may enhance their overall health and wellbeing and, in turn, reduce the burden on the healthcare system. Geriatric assessment and healthcare-related decisions in older adult population should continue to focus on improving the functional status and healthcare-related outcomes in these individuals.

Future research should evaluate the effectiveness of clinical assessment of physical and functional limitations among older cancer survivors and what measures need to be implemented to improve their functional status and reduce morbidity in them. Public heath interventions at community level may be beneficial in strengthening the functional status of older cancer survivors. Education and training of survivors and caregivers may mitigate some of health issues that face the survivors.

Strengths & Limitations

In this study we used a national survey which is representative of the entire older Medicare beneficiary population in the United States. A complete profile of physical and functional limitations of older cancer survivors was obtained from MCBS data. This is a longitudinal study in which we used follow up data to determine the impact of baseline self-assessed health and functional limitations on follow up healthcare utilization and prediction of three-year mortality among the participants. The longitudinal design of the study provided better assessment of the relationship between different variables.

MCBS questionnaires only contain self-reported information which may lead to recall bias. Multiple measures of self-assessed health and various health conditions included in the same model may lead to multicollinearity. Similar to other epidemiological research, cancer survivors in this study refers to individuals who survived cancer treatment, typically after one year of cancer diagnosis (Howlader et al., April 2015). We were not able to measure the duration since cancer diagnosis, the disease severity, and the age at diagnosis. Furthermore, healthcare utilization of older individuals may differ based on the number of comorbidities, history of cancer diagnosis, and type of treatment received for it. In our study, we adjusted for these factors but did not conduct separate analyses by these factors, which may mask the variations in healthcare utilization among older adults.

Conclusion

As the cancer survivor population continues to grow, there is an increasing need to devise improved care models to manage the health of these survivors. Higher prevalence of functional limitations in the rapidly growing older cancer population in the United States demands the delivery of better health care in for them. Coordinated care among primary care physicians, geriatricians, oncologists, and other specialists is the key to improve the health of this population. This study demonstrates that both self-assessed health and measures of physical and functional limitations can significantly predict mortality and health care utilizations among older cancer survivors. Therefore, better assessment of functional status in these individuals will aid in understanding their health status and healthcare needs. Physicians who attend older cancer survivors should proactively incorporate cancer specific geriatric assessment of physical and functional status in their regular practice.

Appendix Table 1: Median Score for Physical Limitations and Functional Limitations (ADL & IADL)

	Good Health		Poor Health	
	Median	IQR (25 – 75%)	Median	IQR (25 – 75%)
Physical Limitations				
Difficulty stooping	2.54	1.20 - 3.84	3.66	2.64 - 4.37
Difficulty walking	2.37	1.00 - 4.22	4.13	3.08 - 4.57
Difficulty reaching	1.00	1.00 - 1.49	1.49	1.00 - 3.11
Difficulty lifting	1.27	1.00 -3.60	3.47	2.14 - 4.37
Difficulty writing	1.00	1.00 - 1.57	1.33	1.00 - 2.63
ADL				
Difficulty bathing	1.34	1.01 - 1.67	1.04	1.00 - 1.52
Difficulty dressing	1.42	1.13 - 1.71	1.23	1.00 - 1.61
Difficulty eating	1.48	1.22 - 1.74	1.44	1.16 - 1.72
Difficulty getting in and out of bed or chair	1.37	1.05 - 1.68	1.02	1.00 - 1.51
Difficulty walking in the house	1.17	1.00 - 1.59	1.00	1.00 - 1.25
Difficulty using toilet	1.44	1.16 - 1.72	1.34	1.01 - 1.67
IADL				
Difficulty in using telephone	1.42	1.12- 1.71	1.30	1.00 - 1.65
Difficulty in doing light housework	1.37	1.03 - 1.71	1.00	1.00 - 1.51
Difficulty in doing heavy housework				
Difficulty in preparing meals	1.39	1.05 - 1.73	1.00	1.00 - 1.53
Difficulty in shopping	1.27	1.00 - 1.65	1.00	1.00 - 1.36
Difficulty in managing money	1.37	1.01 - 1.72	1.23	1.00 - 1.69

Note: IQR – Inter quartile range; ADL - Activities of Daily Living; IADL – Instrumental Activities of Daily Living

Appendix Table II: Stages of ADL and IADL

Stages	ADL Stage	IADL Stage
0 = None	Can eat, toilet, dress, bathe/shower, get in/out of bed/chairs, and walk without difficulty	Can use the telephone, manage money, prepare meals, do light housework, shop for personal items, and do heavy housework
1 = Mild	Difficulty getting in/out of bed/chair and/or walking	Difficulty shopping for personal items and/or doing heavy housework
2 = Moderate	Difficulty dressing, bathing/showering, getting in/out of bed/chairs and/or walking	Difficult preparing meals, doing light housework and shopping for personal items
3 = Severe	Difficulty eating and/or using toilet but not all ADLs	Difficulty using the telephone and/or managing money, but not all IADLs
4 = Complete	Difficulty in all ADLs	Difficulty in all IADLs

CHAPTER 5

CONCLUSION

Summary

The face of cancer has changed over the years owing to early diagnosis, advanced treatment, and improved cancer follow-up care. With increasing age, cancer survivors face more physical and functional limitations compared to people without cancer. Physical limitations, functional limitations and self-assessed health play key roles in the health of older individuals. Older cancer survivors not only have increased healthcare utilization, but also have excess healthcare expenditure even after years of cancer diagnosis, compared to individuals without a history of cancer (Guy Jr et al., 2013). Healthcare professionals need to recognize potential for debilitating functional abilities among cancer survivors and proactively address these issues to facilitate functional independence in their daily living. Stages of functional limitations can be used to assess the functional status of older cancer survivors. In recent times, there is a need to identify and manage survivorship care plans in a more coordinated way to better serve the health of older cancer survivors.

Self-assessed health is a widely-used yet poorly understood health measure to compare and evaluate the health status of individuals (Jylha, M., 2009). However, how self-assessed health status is related to functional limitations and how they impact health care utilization and mortality among older cancer survivors has not been documented systematically in the literature. In our study, self-assessed health status was found to be a valuable and independent predictor of mortality and healthcare utilization among older cancer survivors.

Yet, several questions remain unanswered in assessing the relationship of functional limitations in older cancer survivors. Through this dissertation we have tried to fill in the gap in literature by examining the:

1. Prevalence and factors associated with functional limitation in older cancer survivors.
2. Healthcare utilization among cancer survivors with functional limitations.
3. Independent effects of self-assessed health and functional limitations on mortality and health care use among older cancer survivors

We hypothesized that physical and functional limitations exert a significant amount of burden on older cancer survivors thus increasing the rate of healthcare utilization in them. We defined functional limitations using survey questionnaires from Medicare Current Beneficiary Survey (MCBS).

In addressing the first question, we found that older cancer survivors did not have significantly higher prevalence of functional limitations compared with non-cancer beneficiaries, but they have more physical and functional limitations than those without cancer, resulting in equivalent of one-year loss of physical capacities. This difference is alarming, but this one-year loss of physical capacities may be improved through intervention studies. Such disparities negatively impact the ability of older cancer survivors living independently at home. Public health interventions at an early stage may improve the functional ability of these individuals. In addition, physical therapy and guided physical exercise will help older cancer survivors to function independently at home. Our study calls for health care professionals to incorporate formal assessments of functional status into their regular clinical practice.

Our findings enhanced the understanding of the burden of physical and functional limitations among older cancer survivors. By examining the patterns of limitations and exploring items in each domain, we could identify key barriers faced by these survivors in their daily lives. The higher prevalence of physical limitations among older cancer survivors may be due to the impact of cancer and its treatment on physical functions of the body, as cancer related surgery, chemotherapy, and radiation therapy may have an impact on the physical functions and can often lead to some irreversible changes in the body.

Furthermore, it was seen that cancer survivors were more likely to have multiple comorbidities and disabilities which have been associated with poor mental and physical health (Song et al., 2014). Identifying patterns and mechanisms of functional limitations may be important in preventing or slowing the progression of symptom deteriorations and improving quality of life among this population. Health care needs of older cancer survivors tend to be more disintegrated and disorganized therefore healthcare providers need to pay more attention to the functional status of individuals during their regular clinic visits. Risk estimation of physical and functional limitations may help devise more coordinated and tailored care plans for older cancer survivors (McCabe et al., 2013).

To address our second research question, we constructed healthcare utilization outcome variables using the Medicare dataset. The results from the second study showed physical and functional limitations among cancer survivors exert a substantial burden on the healthcare system. Although there were no differences between the prevalence of physical and functional limitations as well as the rates of hospitalizations between cancer survivors and people with no

history of cancer, the rates of re-hospitalizations and emergency visits were higher among cancer survivors with limitations compared to those without it. The increased use of healthcare can be reduced if these individuals received better coordinated care and counselling on preventive measures of physical and functional limitations during their regular physician visits (Chavan et al., 2017). The average Medicare cost per hospitalization was also found to be higher among older cancer survivors with physical or functional limitations compared to those without these limitations. Cost related to care is a major factor in assessing healthcare expense among these survivors as many of them forgo medical care due to unaffordable cost of care (Kent et al., 2013).

Our study was the first to conduct the examination of this association using propensity score analysis which minimizes the bias introduced by descriptive analysis to examine the association. It also confers to the causal inference criteria thus strengthening the association found in the results of this study. This study demonstrated a stronger impact of physical and functional limitations on the healthcare utilization of older cancer survivors, supporting its public health relevance. Early identification of rehabilitation goals on multidisciplinary level and effective planning for palliative care can help improve the functional status of older cancer survivors. Cost conscious and clinically effective care for these patients may enhance their overall health status and reduce the burden on the healthcare system. Primary care physicians can play a critical role in incorporating assessment of physical and functional status and provide advice on preventive measures to older cancer survivors to improve their overall health and reduce costs associated with excessive healthcare utilizations.

In addressing the third question, we further developed on the self-assessed health status variable to assess the relationship between self-assessed health, physical limitations

and functional limitations, and its impact on health care utilization and mortality among older cancer survivors. Self-assessed health is a tool used to evaluate the health status of individuals. It has also emerged as a predictability tool for length of survival in individuals. MCBS data from 2006 to 2013 was used for examining the above three associations. The results from this study emphasized the importance of self-assessed health as a tool for predicting mortality and health care utilization among older cancer survivors and how strongly self-assessed health is related to physical and functional limitations. The stages of functional limitations can be used to assess the functional status of older cancer survivors.

Healthcare providers need to understand the unique challenges faced by older cancer survivors for self-management of daily activities. A clinically efficient and effective care for these survivors may enhance their overall health and wellbeing and, in turn, reduce the burden on the healthcare system. Geriatric assessment and healthcare-related decisions in older adult population should continue to focus on improving the functional status and healthcare-related outcomes in these individuals. Public heath interventions at community level may be beneficial in strengthening the functional status of older cancer survivors. Education and training of cancer survivors and their caregivers may mitigate some of health issues that face the survivors.

Strengths & Limitations

MCBS is a national survey representative of the entire older Medicare beneficiary population in the United States. A complete profile of physical and functional limitations experienced by older Medicare population and cancer survivors was obtained through the MCBS data for the analysis. This is a longitudinal study in which follow up data was used to determine

the impact of baseline self-assessed health status, physical and functional limitations on follow up years of healthcare utilization and prediction of three-year mortality among the cancer and non-cancer participants. The longitudinal design of the study provided better assessment of the relationship between different variables. Most importantly, the data was analyzed based on the causal inference theory which strengthens the interpretation of results. Propensity score analysis method was used to account for key confounders and ensure the comparability between cancer survivors and those without any history of cancer, thus avoiding over- or under-estimation of the differences in healthcare utilizations between cancer survivors and those without cancer. The results from the studies will add to the literature in better understanding of the impact of physical and functional limitations in healthcare utilization and self-assessed health status.

The study also has a few limitations. The MCBS questionnaires only contains self-reported information which may lead to recall bias. Also, for some participants, proxy answers given by close family members might differ from responses given by the participants themselves. For those who were diagnosed with cancer more than 1 year prior to the survey, there is no information about the age of cancer diagnosis, therefore, we were not able to identify the length of cancer diagnosis for these patients. There is no information on the stage of cancer and severity of disease therefore differences in healthcare utilization by various cancer stages could not be assessed. Although propensity score analysis in theory is preferred for causal inference, it cannot take account of unmeasured confounders therefore the estimates may still be biased. In addition, we excluded participants <65 years of age in all therefore, our results are not generalizable to all cancer survivors. Since the distribution of the original score was skewed to the left we dichotomized the physical and functional limitations variables which may reduce the

granularity of the measure. Furthermore, healthcare utilization of older individuals may differ based on the number of comorbidities, history of cancer diagnosis, and type of treatment received for it. We adjusted for these factors but did not conduct separate analyses by these factors, which may mask the variations in healthcare utilization among older adults.

Clinical Implications & recommendations

As the cancer survivor population continues to grow, there is an increasing need to devise improved care models to manage the health of these survivors. Higher prevalence of functional limitations in the rapidly growing older cancer population in the United States demands the delivery of better health care for them. Coordinated care among primary care physicians, geriatricians, oncologists, and other specialists is the key to improve the health of this population. Advanced practice providers should provide collaborative care to cancer survivors in concordance with the standards of IOM. Primary care practitioners are an essential part of the multidisciplinary team caring for cancer survivors, therefore continual communication within the team and delineation of role in providing care is essential for better health outcomes in these survivors. Establishing clear guidelines, clarifying roles and responsibilities of care providers, evaluation of essential practice components and timely training and education of cancer survivors and their care givers will enhance the quality of care received by these individuals.

Bridging the gap between specialists and primary care physicians is the key in planning the survivorship care for these individuals. The advent of patient-centered care is requiring primary care physicians to maximize the health of patient population.

Inclusion of primary care physicians from treatment planning to after discharge care is vital in caring for older cancer survivors. A more coordinated survivorship care workforce is required to deal with issues such as access to care and shortage in healthcare workforce, so that the supply could meet demand. Education and training of primary care professionals on cancer survivorship issues is needed for continued cancer care.

Public health implications & recommendations

Beyond the need to address issues related to physician coordination and organization of the delivery care structure, the 2013 Institute of Medicine (IOM) report also emphasized on the increasing need for survivorship care and palliative care (Hurria, Naylor, & Cohen, 2013; Mitka, 2013). The fragmented delivery care system, lack of clarity on delivering different aspects of cancer care and barriers to accessing care are all important issues that need to be addressed for better survivorship of the older cancer survivors (Lee, J. & Johnson, 2013).

Implementing an official structured cancer survivorship program will serve better after treatment care for older cancer survivors. Promoting enhanced emotional health in these individuals, especially related to the survivor's quality of life, identifying and providing required information for improved health, and arranging access to needed resources are some of the important factors that need to be implemented at the community level (Mayer, Deborah K., Nasso, & Earp, 2017). For example, the local health departments and non-profit peer-support groups or organizations could form local community care groups where survivors could provide emotional and tangible support to

each other., in which lead advisers could navigate the group using informational support for the survivor group (Landon, Grumbach, & Wallace, 2012).

It is imperative that a public health officer working towards the betterment of a community should work with a primary care physician treating patients from the same community to address the myriad health problems faced by the older cancer survivors. Bridging the gap between the two worlds is required to effectively serve the cancer survivor population. The primary care physician may be able to do a better job at counselling and prevention if information about affordable community resources are shared with them by the local public health departments (Committee on Integrating Primary Care and Public Health Board on Population Health and Public Health Practice Institute of Medicine, 2012). Lifestyle intervention development studies to improve physical and functional ability in older cancer survivors should be implemented in local communities by public health departments. A combination of public health interventions channelized by palliative care can help improve the health of the older cancer survivor population which may in turn reduce the burden on the healthcare system.

Suggestions for future research

The number of long-term cancer survivors is expected to increase dramatically bringing with it challenges that characterize the cancer survivorship phase of these individuals ((Bazzell et al., 2015). Although the need for a structured cancer survivorship plan has been emphasized, there is a lack of evidence-based research which can directly address the formation of comprehensive follow-up care. Future research should evaluate the clinical effectiveness in assessing physical and functional limitations among older

cancer survivors and what measures need to be implemented to improve their functional status and reduce morbidity in them. Public health interventions at community level may be beneficial in strengthening the functional status among these older individuals. Furthermore, better healthcare models and strategies connecting clinical issues with public health concerns for older cancer survivors will pave the path towards more optimal solutions. Improving the health and well-being among these patients will invariably reduce the overall burden on the healthcare system.

Directions for future research should focus on the following:

1. Due to decrease in functional limitations with aging, community level intervention studies in older adults are required which can focus on ways to improve the functional status of older individuals.
2. Research focusing on effective healthcare models with patient centered care which can effectively coordinate care and communication between primary care physician and the specialist.
3. Future studies need to come up with efficient ways to disseminate health information among patients and their families with use of modern technology.
4. Physical, psychological, self-rated health have independent effects on mortality and healthcare use. Future research should examine each of these areas of care and find association between them.
5. Include local and state level public health workers in the development of shared care models.

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