



Lower levels of education and household income mediate lower dental care utilization among survivors of early life cancers^{☆, ☆☆}

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ABSTRACT

This study was an examination of dental care utilization among survivors of early life cancers (cancer diagnosis at 20 years of age or younger) and the extent to which socio-economic factors may present a barrier to care. Data were obtained from the National Health and Nutrition Examination Survey (NHANES) from 2007 to 2016 (n = 28,640). Survey-weighted regression models were used to evaluate associations between early life cancers and subsequent frequency of dental care as adults. A mediation analysis was conducted to test education and household income as potential mediators of this association using a non-parametric bootstrap approach.

Early life cancers were associated with a significant decrease in dental care utilization as adults (OR:0.459, 95%CI:(0.226, 0.935)). This diminished utilization was particularly pronounced with survivors in their 20s and 30s. Over time dental care utilization began a slow recovery. The association between early cancer and level of education was estimated to be negative but did not reach statistical significance (OR:0.739, 95%CI:(0.503, 1.086), $p = 0.123$). Survivors of early life cancers were less likely to be in a higher income bracket (OR:0.663, 95%CI:(0.452, 0.973), $p = 0.036$). Decreases in education and household income ($p < 0.001$) mediated the association between early cancers and lower dental utilization. This pathway accounted for 41.7% (95%CI: (14.1%, 50.6%)) of the association.

Survivors of early life cancers did not utilize professional oral health care at a rate commensurate with their risk of dental disease. Providers involved in the long-term care should promote routine dental maintenance. Further study into non-economic barriers in this population is warranted.

1. Introduction

Cancer and its therapy result in numerous, long-lasting effects on survivors. These effects are particularly poignant in the pediatric population where physiologic effects of cancer and cancer therapy on normal growth and development can produce profound symptom control and functional issues that result in a greater need for multi-disciplinary supportive care. The predisposition of this population to chronic health conditions and the numbers of ways in which these conditions detract from survivors' quality of life have been demonstrated (Oeffinger et al., 2006; Yeh et al., 2016).

Unfortunately, the implications of early life cancers on survivors' dentition and oral health habits are understudied. Higher rates of dental anomalies have been well established (Jaffe et al., 1984; Nunn et al.,

1991; Maguire et al., 1987; Avsar et al., 2007) with additional evidence pointing to higher risk of dental caries (Avsar et al., 2007; Wogelius et al., 2008). This greater susceptibility suggests that these survivors may benefit from more intensive oral maintenance. Nonetheless, both patients and providers may be unaware of the greater risk of dental problems. Furthermore, research suggests that patient recognition of the greater risk for poor dental outcomes, does not necessarily translate to better oral hygiene practices (Mulhern et al., 1995). In particular, Mulhern et al. demonstrated that in a cohort of survivors of early life cancer, the majority of survivors believed that it was 'more important' for them to maintain good health than it was for other people. This belief was even more prevalent in parents of survivors, the majority of whom endorsed the statement that it was 'much more important.' However, in both the pre-adolescent and young adult strata, this belief

Abbreviation: NHANES, National Health and Nutrition Examination Survey

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in the importance of good oral care did not translate to increased health protective behaviors. Approximately 25% of respondents in the pre-adolescent and young adult strata endorsed that they brushed their teeth once per day or less.

In addition to the known physiologic changes, a number of potential dental care barriers may exacerbate the observed greater risk of dental disease in survivors of early life cancers. Cancer early in life can have lasting socio-economic impact on the patient (de Boer et al., 2009; de Boer et al., 2006; Mehnert et al., 2013; Mitby et al., 2003; Parsons et al., 2012; Robison et al., 2005), with survivors often obtaining less education (Mitby et al., 2003; Parsons et al., 2012; Robison et al., 2005; Gurney et al., 2009), having a higher rate of unemployment (de Boer et al., 2009; de Boer et al., 2006), and having difficulty leaving an existing job due to the need to maintain insurance to manage chronic health conditions (Kirchhoff et al., 2017). Further, in the adult population there is evidence that the relationship may be bidirectional with poverty being considered a risk factor for many cancers (Ward et al., 2004). How these educational and financial implications of early cancers influence dental care has not been evaluated in early life cancer survivors. A conceptual model for how early life cancers may influence future dental care utilization is given in Fig. 1.

Adult cancer survivors utilize professional oral care less after cancer therapy (Smith et al., 2018). If this observation holds true among early life cancer survivors, the adverse impact on long-term oral health and quality of life may be substantially greater because of the extended duration of survivorship. Longer periods of survivorship allow for time for late effects to develop. In this manuscript, we examine frequency of professional oral care in survivors of early life cancers. Further, we examined the association between socio-economic indicators on professional care use.

2. Methods

2.1. Data

Data were obtained from the National Health and Nutrition Examination Survey (NHANES) including surveys administered from 2007 to 2016 (Center for Disease Control and Prevention (CDC) and National Center for Health Statistics (NCHS), 2018). NHANES is a nationally representative, cross-sectional study that collects demographic, survey, and examination data every two years. It is administered by the National Center for Health Statistics. Participants in this timeframe who completed the demographic, medical conditions, and oral health surveys were included in the analysis (n = 28,640). This missingness is the result of the NHANES sampling scheme which was designed in such a way that a representative sample can be achieved using the appropriate sampling weights.

Information on dental care utilization in the NHANES is categorical. Consequently, analyses of dental utilization in this manuscript will focus on whether the participant reports having visited a dentist in the previous year. Education level is a categorical response from 1 to 5 representing: less than 9th grade, 9–12th grade with no diploma, high school graduate/GED, some college or AA degree, and college graduate or above respectively. Income was similarly categorical and was recoded to be a categorical variable ranging from 1 to 12 with the lowest group representing \$0–\$4999/year and the highest group represents > \$100,000/year. For our purposes, we defined an early life cancer as reporting a cancer diagnosis prior to age 20. No one was excluded based on age. Due to concerns about overfitting the statistical model, race information was categorized by Caucasian vs. minority as it was a priori believed that this would best convey the disparities among races for the purposes of adjusting the odds ratio.

2.2. Statistical analyses

Due to the sampling scheme used by the NHANES, survey-weights need to be applied to statistical analyses to ensure that the results will generalize to the US population. All analyses performed in this manuscript followed the weighting guidelines provided by the NHANES. Logistic regression with survey weights was used to examine dental care utilization with whether the patient reported a dental visit in the past year being the dependent variable.

Education and household income were examined using proportional odds models for ordered, categorical outcomes. Categorical covariates were modeled continuously in order to preserve their rank order. Mediation analyses were performed by applying a non-parametric bootstrap to survey-weighted logistic regression models. The non-parametric bootstrap procedure was also used to calculate the 95% confidence region for the percent of the association between early cancer and dental utilization that was mediated by these socio-economic indicators. All analyses were performed using R version 3.3.2.

3. Results

Of the initial 40,114 people participating in NHANES during the specified timeframe, n = 28,640 completed the information necessary for inclusion. Of those who completed the necessary information for inclusion, 44 were survivors of early life cancers. Summary data for these patients are given in Table 1. Each variable was used in the grouping depicted in Table 1.

The analysis of dental utilization (defined as reporting a dental visit in the past year) demonstrated that survivors of cancer early in life were substantially less likely to report having seen a dentist in the last year (OR: 0.421, 95%CI: (0.205, 0.869), p = 0.019) after adjusting for age

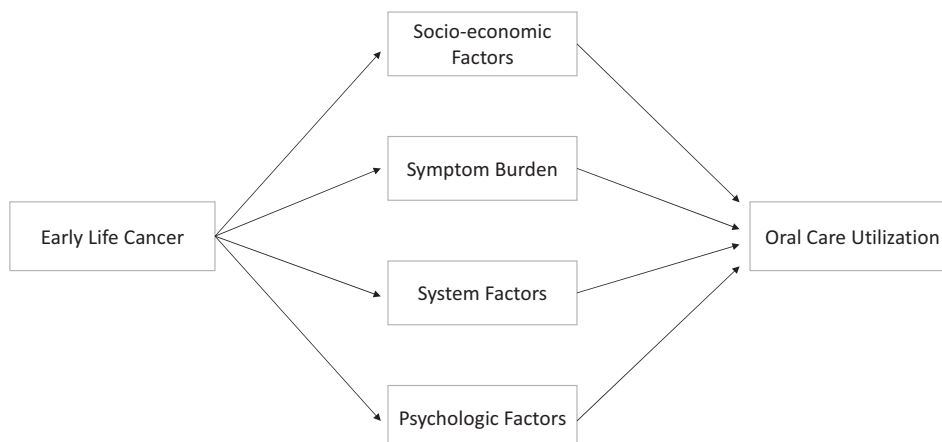


Fig. 1. Conceptual diagram of how early life cancers may impact future dental care utilization.

Table 1
Demographic information of included subjects - Entries are given as count (proportion) except in the case of age which is given as mean (standard deviation).

	Early cancer	General population
	n = 44	n = 28,596
Male sex	13 (29.5)	14,177 (49.4)
Age (y)	37.84 (15.25) Range: [20, 80]	32.91 (24.22) Range: [1, 80]
Race		
Caucasian	37(62.7)	19,293 (67.5)
Minority	22(37.3)	9288 (32.5)
Education		
< 9th grade	3 (6.8)	1684 (9.9)
9–12th grade no diploma	8 (18.2)	2234 (13.2)
High school graduate	6 (13.6)	3692 (21.8)
Some college or AA degree	24 (54.5)	5091 (30.0)
College graduate	3 (6.8)	4257 (25.1)
Household income		
0–\$4999	0 (0.0)	762 (3.0)
\$5000–\$9999	5 (11.9)	1195 (4.6)
\$10,000–\$14,999	3 (7.1)	1821 (7.1)
\$15,000–\$19,999	3 (7.1)	1894 (7.4)
\$20,000–\$24,999	5 (11.9)	2180 (8.5)
\$25,000–\$34,999	6 (14.3)	3169 (12.3)
\$35,000–\$44,999	5 (11.9)	2666 (10.4)
\$45,000–\$54,999	6 (14.3)	2095 (8.1)
\$55,000–\$64,999	2 (4.8)	1484 (5.8)
\$65,000–\$74,999	1 (2.4)	1239 (4.8)
\$75,000–\$99,999	1 (2.4)	2462 (9.6)
> \$100,000	5 (11.9)	4741 (18.4)

and sex. A non-parametric regression examining attendance over age suggested that this discrepancy may be driven largely by a very low rate of dental care utilization from the 20s and early 30s, which then slowly recovers. Fig. 2 depicts the difference between the non-cancer population and the early cancer survivors' use of professional dental care. The first panel depicts a nonparametric loess regression model to estimate the proportion of participants who would report a dental visit in the past 12 months. The second panel of the figure is the difference between the two curves given in the first panel and its 95% confidence interval generated by a nonparametric bootstrap procedure. Table 2 gives the unweighted frequency of utilization reported by those with and without an early life cancer.

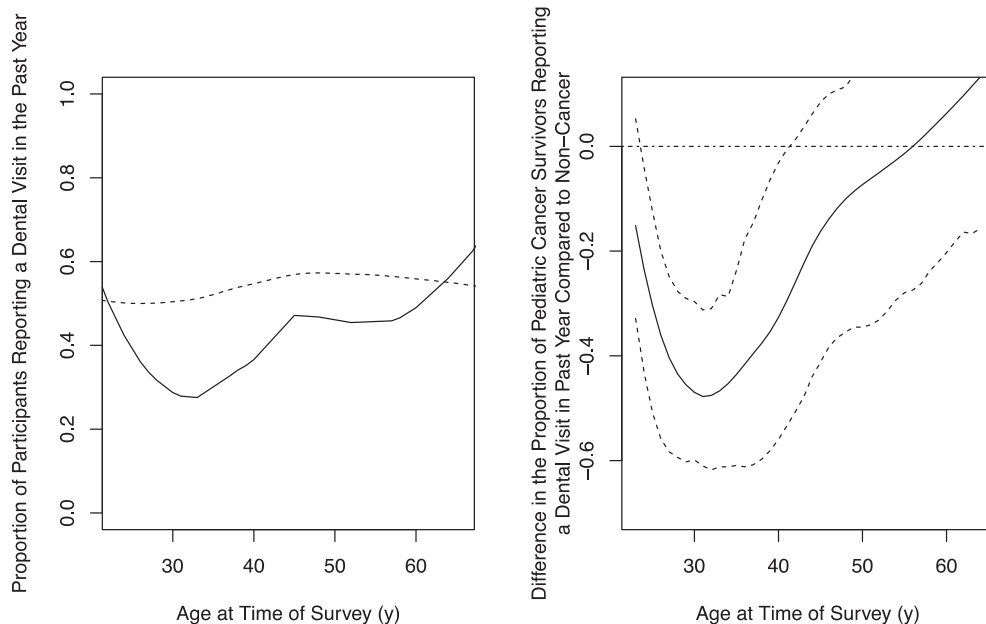


Fig. 2. (Left panel) This panel depicts the proportion of participants that report a dental visit in the past year for the general population (dashed) and survivors of pediatric cancers (solid). (Right panel) This panel depicts the difference in the proportion of early life cancer survivors reporting dental care and those without an early cancer. This difference (solid line) is presented with a bootstrap 95%CI (dashed lines). The zero-line representing no difference between the groups is marked for reference.

Table 2
Frequency of dental visits among early cancer survivors and the general population.

Frequency of dental visitation	Early cancer n (%)	General population n(%)
6 months or less	13 (29.5%)	13,172 (46.1%)
> 6 months, but not > 1 year ago	6 (13.6%)	4517 (15.8%)
> 1 year, but not > 2 years ago	8 (18.2%)	2980 (10.4%)
> 2 years, but not > 3 years	6 (13.6%)	1671 (5.8%)
> 3 years, but not > 5 years ago	3 (6.8%)	1464 (5.1%)
> 5 years ago	8 (18.2%)	2767 (9.7%)
Never have been	0 (0%)	2005 (7.0%)

In this data set, there was a negative association between education and early life cancer, adjusted for age, minority status, and sex, (OR:0.727, 95%CI:(0.548, 0.963), $p = 0.026$). A similar model examining household income which also adjusted for age, minority status, sex and education level indicated that there was a significant decrease in income in survivors of early life cancers (OR:0.573, 95%CI:(0.387, 0.847), $p = 0.005$).

Mediation analysis was performed using the survey weighted linear models with education and household income being considered jointly as potential socio-economic mediators of the established association between early life cancer and dental utilization. The analysis suggests that 43.9% (95%CI: (19.7%, 56.3%), $p < 0.01$) of the association is mediated by lower levels of education and income.

A survey weighted chi-square test was used to compare the reasons for participants' last dental visit. There was a significant difference between early life cancer survivors and the other participants ($p = 0.010$). Examining the individual responses, early life cancer survivors were significantly more likely to identify the cause of the visit to be 'Something was wrong, bothering, or hurting' than the general population (OR:2.17 95%CI:(1.41, 4.13), $p = 0.018$). Similarly, the survivors were less likely to endorse 'Went in on own for check-up, examination, or cleaning' (OR:0.528, 95%CI:(0.288, 0.970), $p = 0.039$).

4. Discussion

This data supports the assertion that early life cancer survivors are seeking less dental care than the general population despite having a greater risk of dental problems. This problem manifests in the early to

mid-20s (around the time when most of the survivors would be becoming socially and financially independent), and persists through the mid-30s after which a gradual recovery in the rate of dental utilization is observed. It is unclear why dental utilization increases as patients reach their mid to late 30s. There are several potential explanations. It may be that this is usual timeframe from serious dental issues to begin to manifest or that it takes a number of years for patients whose parents took a larger role in their health care early in life to develop self-care skills. The first of these hypotheses is supported by the data suggesting that the proportion of dental visits due to 'Something was wrong, bothering, or hurting' increases around the same age.

There are a number of potential barriers to early life cancer survivors seeking dental care that can be hypothesized. Residual symptom burden secondary to cancer therapy such as chronic fatigue may either supersede or impede patients from seeking dental care. Chronic illness and debility may create a substantial overall self-care burden which requires patients to prioritize their activities. Professional dental care may be a lower priority. Dental anxiety is a major compliance issue among the general population. Survivors of early cancers may have increased anxiety associated with medical care and medical instructions which may be particularly intense with regards to dental care. Patients who survive early life cancers may have stunted development of self-care skills, and insurance/financial barriers. This hypothesis remains largely unexplored for specific self-care tasks, however, it has been demonstrated that survivors of early life cancers are at greater risk for functional limitations that impair their functional capacity, ultimately effecting their ability to perform activities of daily living (Ness et al., 2005; Ness et al., 2009). The hypothesis is further supported by the evidence presented here suggesting that early cancer survivors' dental visits are more likely to be motivated by an acute issue, and merits further research.

Given the established detrimental effects of early life cancer on socio-economic development, it would be reasonable to expect that education and household income would mediate the vast majority of the association. Thus, we examined the impact of education and finances. We found that both education and household income play a substantial role in professional oral care use; however, the association was less than had been anticipated. Additional research into potential barriers to dental care in this population are warranted. These studies are needed to help direct interventions that may improve oral care utilization in survivors of early life cancer.

The data relating to household income provides further evidence demonstrating that having an early cancer is associated with substantially reduced odds of reaching a higher category of income. The proper interpretation from this type of model is that survivors of early cancers' odds of being in a higher income bracket were roughly 33% less than someone without an early cancer and similar age, sex, and education level. The association between early life cancer and education was significant, and supports the results of previous studies that have identified this relationship (Mitby et al., 2003; Parsons et al., 2012; Robison et al., 2005; Gurney et al., 2009).

Preventative dental care is the cornerstone of modern oral health. Recognizing dental issues in a timely fashion and remediating dental disease before it progresses results in the best outcomes for patients at the lowest cost. These data suggest that this is precisely the aspect of oral care that is being overlooked by early cancer survivors who were far more likely to report visits being due to more urgent dental issues. It is critical that all members of the health care community that contribute to the care of those with early life cancer recognize the need for multidisciplinary, preventative supportive care and actively promote a team-based approach. Visits with any health care provider should be seen as an opportunity to promote whole-patient care including promotion of good oral health and the need for professional routine care.

This study is limited by being based on data from a voluntary survey. However, the NHANES is meticulously conducted and great

care is taken to ensure the weights provided with the data account for the sampling scheme. This study is further limited by the low event rate observed by the NHANES. Having only 44 survivors among the included 28,640 patients limits the precision of the analysis. Additionally, the selective sampling employed by NHANES could impact the results in small samples. The collection of education and income as categorical rather than continuous variables also limited the power of the analyses. In addition, data on specific cancer diagnoses are not collected.

Survivors of early life cancers are underutilizing professional oral health care, and particularly are seeking less care through their 20s and 30s. Patients are more likely to seek oral health care if they perceive an active dental problem as opposed to seeking preventive care. Although lack of routine oral health care is partially mediated by lower income and less education, these factors are responsible for less than half of the overall association. Further barriers research in this population is warranted to guide future interventions. Providers involved in the long-term care of these patients should take an active role in promoting good oral health and the importance of routine, professional oral care.

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