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ORIGINAL ARTICLE

Financial and socio-economic factors influencing pre- and post-cancer therapy oral care

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Abstract

Purpose The primary objective of this study is to evaluate how attendance at dental visits may change as cancer patients move through pre-diagnosis, diagnosis, and into survivorship.

Methods The Health and Retirement Study consists of longitudinal survey data collected biannually detailing financial and health information in subjects over 51 years old. We assessed a subset of 4195 patients who received a new cancer diagnosis during the study period. The odds of reporting a dental visit were examined using a mixed effects logistic regression model. A propensity score weighted analysis of the association between dental attendance and survival was also undertaken.

Results The odds of attending a dental visit were substantially lower in the peri-diagnosis period OR = 0.784 (0.700, 0.876) and the post-diagnosis period OR = 0.734 (0.655, 0.823) compared to pre-diagnosis. This effect persisted in patients who survived for at least 2 years indicating that the decline in oral health visits was not due to low expected survival. After propensity score weighting, patients who attended a dental visit in the peri-diagnosis period demonstrated a reduced hazard of all-cause mortality HR = 0.825 (0.681, 0.979) compared with those with no attendance.

Conclusions Dental attendance decreases by a statistically and clinically significant amount both during and after cancer therapy despite guideline recommendations encouraging dental referral and monitoring for many types of cancer therapy. Attendance at dental appointments during cancer therapy is associated with improved survival, which is likely due to a combination of direct and indirect effects.

Keywords Pre-treatment dental evaluation · Dental attendance · Survivorship · Health and retirement study · Oral care utilization

Introduction

The negative effects of cancer therapy on oral health have a significant impact on general health and quality of life [1–6]. Multiple cancer therapies, including chemotherapy, bisphosphonates, head and neck radiation, stem cell transplant therapies, and targeted therapies, can all lead to substantial oral complications [7–11]. Based on current guidelines, patients should be referred for oral evaluation prior to initiation of cancer treatment [11–16]. The oral evaluation affords the cancer team the opportunity to identify and address dental problems before initiation of treatment, thus potentially preventing acute and long term oral health complications. In addition, cancer patients also require close follow-up care during and after their treatments have concluded to ensure adequate preventive measures and to monitor for acute and late oral health toxicities.

A number of factors contribute to poor adherence to oral health guideline. Not all patients with a cancer diagnosis receive appropriate pre-treatment assessment of dental health. In addition, patients often fail to comply with routine follow-up care. More importantly, patients with clinically evident oral complications requiring dental evaluation may decline to seek appropriate care. Finally, patients found to have oral health complications may not comply with recommended treatment regimens. The degree to which the above problems exist in the cancer patient population has not been well defined. Furthermore, the barriers to oral health care have yet to be

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adequately studied. A number of potential barriers to care may be postulated. First, treating oncologists or radiation oncologists may fail to refer for pre-treatment evaluation. Second, patients may receive inadequate education regarding the importance of oral health care and maintenance. While medical insurance often provides coverage for pre-treatment dental extractions, it seldom covers long-term care and many patients may lack financials for dental insurance or the ability to pay out of pocket. It is of paramount importance that the barriers to sufficient oral care are well understood so that they may be addressed efficiently.

The primary objective of this study is to evaluate attendance at dental visits among patients receiving a cancer diagnosis, and how attendance may change as patients move through pre-diagnosis, diagnosis, and into survivorship. This study uses survey data from the Health and Retirement Study (HRS) [17]. The HRS is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan. This study collected panel data on individuals 51 years of age and older from around the nation and details their financial situation as well as documenting select health events, demographic information, and whether the patient had a dental visit in each survey period. A pragmatic assessment of oral care services among newly diagnosed cancer patients was undertaken to determine whether a cancer diagnosis was associated with an increase in self-reported dental visits as would be expected based on guideline recommendations. Any education patients may have received on the oral aspects of cancer treatment was presumably received in the survey interval that contains the new cancer diagnosis. The probability of reporting a dental visit in the diagnosis interval and subsequent intervals can therefore give insight on the efficacy of current oral health education practices and oral health maintenance behaviors.

Methods

The Health and Retirement Study (HRS) is a nationally representative, longitudinal survey of more than 37,000 adults over age 50 which collects demographic, health-related, and financial information through biennial household interviews. This analysis used 11 survey intervals of publically available data spanning 1992–2012. Throughout this study, each wave of the survey will be referred to as an interval. The period in which patients are diagnosed will be defined as the diagnosis interval and thereafter survivorship intervals.

This analysis used the data on HRS participants who reported a newly diagnosed cancer at some point during the study period, $n = 4195$. New cancer cases were identified by an affirmative response to the question: "Since we last talked to you, that is since [last interview date], has a doctor told you that you have cancer or a malignant tumor of any kind except skin cancer?" Of note, due to the nature of the question, new cancer cases could not be identified during the 1992 interval (wave 1 of the survey) of the HRS, although data collected during this interval could be incorporated into the regression and descriptive analyses. Similarly, if respondents entered the HRS after this interval, the presence of a new cancer diagnosis would be assessed from their second interview onward. The average number of survey intervals completed was 9.7. Missing values for socio-economic variables that do not vary with time (i.e., race and gender) were rare as they were recorded in each survey interval allowing completion of missing values by inputting the value from a non-missing interval. In cases where dental visit information was missing for a pertinent survey interval, that interval was omitted and assumed to be missing completely at random. Missing data on participants' insurance and household income was imputed from observed information including the patient's recorded values in the intervals before and after the missing value.

The primary analysis was conducted using a random-effects logistic regression model to account for the longitudinal nature of the data. An indicator variable was included which identified the interval in which the new cancer diagnosis was made and a second indicator identified subsequent intervals. Secondary analyses were conducted to look for interactions between each of the race, gender, years of education, and household income and the indicator of the diagnosis interval and post-diagnosis intervals. If significant, these interactions would indicate disparities in how the cancer therapy treatment pipeline affects patients' eventual utilization of pre- and post-therapy dental services, respectively.

The predicted probabilities from the logistic model were used to generate propensity score weights [18]. These weights were used to analyze time to all-cause mortality via weighted Kaplan-Meier curves, weighted log-rank test, and a weighted Cox proportional hazard model. Interval censoring was handled using imputation [19].

Results

The demographic information of the included participants is summarized in Table 1.

The random-effects logistic regression of dental visit attendance was adjusted for whether the interval contained a new cancer diagnosis; whether the interval was post-diagnosis or household income; and whether the patient had an employer-based medical insurance, African-American race, other non-white race, years of education, gender, and age. Household income was standardized prior to model fitting due to its large variation compared to the other variables to be included, and therefore, a one unit change in income represents a one standard deviation change on the original scale. The corresponding odds

Table 1 Demographic information for the included participants

n	4195
Continuous variables (mean (sd))	
Household income	60,442.21 (103,836.46)
Age	58.63 (11.06)
Years of education	12.25 (3.33)
Categorical variables (count (%))	
Female gender	2011 (47.9)
Race	
Caucasian	3475 (82.8)
African-American	587 (14.0)
Other	133 (3.2)
Employer medical insurance	1682 (40.1)
Dental attendance (average (95%CI))	
Pre-cancer therapy intervals	62.4% (61.2, 63.8)
Diagnosis interval	58.9% (57.4, 60.5)
Post-diagnosis intervals	59.9% (58.4, 61.5)

ratios are given in Table 2. Each covariate was associated with a statistically significant p value. During the interval, in which the new cancer diagnosis is made in comparison to pre-diagnosis intervals, the odds ratio of attendance at a dental visit was 0.784 (0.700, 0.876), $p < 0.001$. The analysis was repeated including only patients who survived to provide data in two subsequent intervals, and the odds ratio was nearly unchanged. Post-diagnosis intervals compared to pre-diagnosis intervals demonstrated an odds ratio of 0.734 (0.655, 0.823), $p < 0.001$. The area under the receiver operating characteristic curve (AUC) was 0.941 indicating that the model gives excellent discrimination, Fig. 1. A

Table 2 Odds ratios from mixed effects logistic regression model relating socio-economic factors to self-reported dental appointment attendance. The diagnosis interval odds ratio applies to the survey interval in which the cancer diagnosis was made. The post-diagnosis interval applies to all intervals subsequent to the interval in which the cancer diagnosis was made

Covariate	Odds ratio
Diagnosis interval	0.78 (0.70, 0.87)
Post-diagnosis interval	0.74 (0.66, 0.83)
Household income	2.24 (1.96, 2.56)
Employer insurance	1.58 (1.42, 1.77)
African-American	0.43 (0.33, 0.55)
Other non-white	0.61 (0.37, 0.99)
Years education	1.37 (1.33, 1.42)
Female	1.35 (1.13, 1.60)
Age	0.99 (0.98, 0.995)

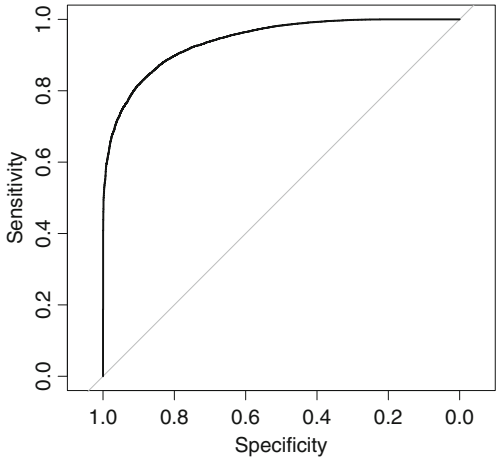

Fig. 1 Receiver operating characteristic curve for the mixed effects logistic regression model relating socio-economic status to dental appointment attendance

calibration plot of the model predicted values against a loess smooth of the observed values indicated that the model is also well-calibrated.

Secondary analyses added an interaction term between various demographic factors and whether the interval contained a new cancer diagnosis in order to determine whether the decrease in oral care is more or less severe based on socio-economic factors. The interaction terms were not significant in any of these following models: African-American race ($p = 0.789$), male gender ($p = 0.596$), years of education ($p = 0.304$), and household income ($p = 0.680$). Further analyses looked at the interaction terms of the same socio-economic variables with the indicator for being a post-diagnosis interval to determine if the decrease in the odds of dental attendance that pervades the post-diagnosis intervals was related to specific socio-economic factors. These models also produced non-significant interaction terms for African-American race ($p = 0.415$), male gender ($p = 0.319$), household income (0.983), and years of education ($p = 0.331$) indicating that the decrease in attendance is consistent across various socio-economic groups.

The predicted probability of dental attendance from the mixed effects model was used to generate a propensity score weight. This weighting scheme resulting in improved comparability between the two groups, Table 3. Weighted Kaplan-Meier curves were generated for time to all-cause mortality stratified by whether or not the participant reported a dental visit in the interval in which their cancer was diagnosed, Fig. 2. A weighted log rank test suggested a statistically significant survival benefit amongst those reporting a dental visit, $p = 0.0391$. A propensity-weighted Cox model was also fit adjusting for any residual imbalance in age, race, gender, years of education, and household income. The hazard ratio for reporting a dental visit was 0.825 (0.681, 0.979), $p = 0.0381$.

Table 3 Distribution of covariates by dental appointment attendance in the diagnosis interval before (left) and after (right) propensity score weighting

	Raw data		Weighted data	
	No dental	Dental	No dental	Dental
Household income	34,961.84 (33,047.83; 36,875.85)	67,457.28 (64,764.41; 70,150.14)	44,473.83 (42,405.74; 46,766.37)	40,547.29 (39,079.98; 42,056.07)
Age	71.56 (71.10, 72.04)	70.22 (69.83, 70.61)	70.35 (69.91, 70.77)	71.21 (70.75, 71.65)
Gender (% male)	53.65% (51.21, 56.07)	51.13% (49.10, 53.16)	53.0% (50.6, 55.5)	53.0% (51.0, 55.0)
Race (% Caucasian)	76.52% (74.39, 78.53)	87.10% (85.66, 88.40)	75.0% (72.8, 77.0)	72.0% (70.1, 73.8)
Education years	10.94 (10.77, 11.10)	13.14 (13.02, 13.26)	12.01 (11.88, 12.14)	11.52 (11.37, 11.67)

Discussion

Our data support a decrease in the probability of cancer patients seeing an oral health provider at the time of diagnosis or any time thereafter. This observation is counter to what would be expected if current guidelines were being followed. If oral health referrals are being made in a timely manner and oral health maintenance education is being conveyed effectively it would be expected that the diagnosis and post-therapy intervals would demonstrate higher odds of dental attendance than pre-treatment intervals. The increase in attendance would be a direct result of an increase in pre-treatment and routine health maintenance visits by the portion of the population at increased risk and the maintenance of pre-treatment levels of care by those whose therapy did not affect their risk of oral disease. In addition, the increased incidence of oral health problems associated with many types of cancer therapy would contribute to the predicted increase in oral health visits.

The estimated 20% reduction in the odds of seeking dental care at the time of and following a cancer diagnosis is a concerning finding. This decrease was demonstrated when the analysis was restricted to patients surviving for at least two subsequent survey intervals (i.e., minimum survival time of 2 years), reducing the likelihood that the drop in dental visits is due to patients with short-expected survival neglecting their oral health. The estimated decrease in the odds of dental attendance in post-diagnosis intervals was even greater than in the diagnosis interval. Although this result could still be the result of a shortened-expected survival time, it is not generally recommended that patients would go multiple years without having an oral exam. The finding represents significant evidence that the barriers to adequate dental care during and after cancer therapy are not being adequately addressed by current practice.

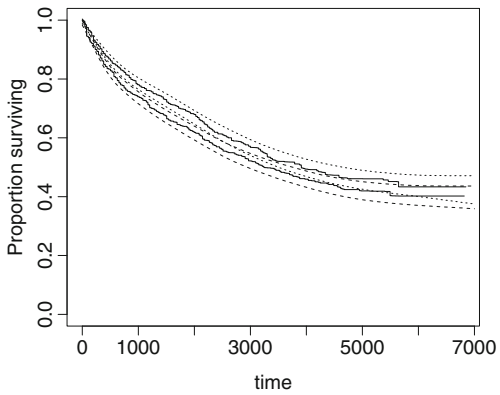

Fig. 2 Kaplan-Meier curves for patient survival time in days who reported a dental visit in the survey interval containing their cancer diagnosis (top) versus those with no visit in their diagnosis interval (bottom) with 95% confidence intervals

We attempted to identify predictors for decreases in oral health utilization. Substantial reductions in the odds of seeking care in any time frame were evident by income, type of medical insurance, African-American race, gender, and years of education. However, the magnitude of change was consistent across race, gender, education, and income level suggesting that the decline in dental visits associated with a cancer diagnosis cannot be explained by socio-economic barriers alone. However, while no evidence of socio-economic disparity was apparent in the decrease in the odds of seeking dental care following a cancer diagnosis, this does not mean that socio-economic barriers do not exist. Rather, it means that the decline in dental attendance associated with receiving a cancer diagnosis acts independently of the clearly evidenced socio-economic barriers that already exist. Substantial reductions in the odds of seeking dental care were evident for those with reduced income, those who did not have employer-sponsored medical insurance, African-American race, male gender, and lower education level. Although we cannot rule out that these demographic groups had early tooth loss, therefore required less frequent dental care, the disparities suggest that public health initiatives need to be undertaken to further investigate contributing factors. The urgency to address disparities is magnified in the cancer population where good oral health's importance is amplified by post-treatment physiologic changes. For example, patients who undergo radiation therapy for a head and neck cancer often experience hyposalivation that can lead to radiation dental carries and tooth loss.

As expected, evidence of financial barriers exists with increasing household income being associated with an increase in the odds of seeking dental care at any time. Although the study did not collect information on whether participants had dental insurance, whether the patient had an employer-based medical insurance which was used as a proxy as it would cover some aspects of dental care in certain situations. Having such coverage improved the odds of seeking dental care by 51%. It is clear that both income- and insurance-related economic barriers exist.

Additional barriers to dental care include beliefs, knowledge, and behaviors. Patients and care providers may believe that dental care is less important in patients with advanced cancers resulting in decreased referrals and emphasis of dental health maintenance. Knowledge about the ramifications of adverse dental outcomes and optimal preventive measures may be lacking among providers or providers may not adequately communicate knowledge about oral health care to patients. Finally, patients may be overwhelmed by their other medical obligations resulting in the diminished adherence to oral care regimens and follow-up.

Although far from establishing a causal relationship, our data indicated an improved survival among patients who reported a dental visit in the interval in which their cancer was diagnosed suggesting potential mechanisms which merit further investigation. The first potential source of this survival benefit is a direct benefit of improved oral health. Better oral health could directly produce the measured benefit by lowering the patient's immediate risk of infection, decreasing total inflammatory burden, and improving nutritional status including weight maintenance and adequate intake of micro/macronutrients. Another potential mechanism for the observed survival benefit is that patients seen by multidisciplinary teams that embrace supportive care including oral health may have better overall survival rates. Lastly, we cannot rule out the possibility that those who discover their cancer when it is at a terminal stage may be less likely seeking out dental treatment. This effect is unlikely to comprise the majority of cases given the exceptional ability of the fit logistic regression to predict dental visits, but could be effecting the estimate of the overall benefit. Further studies are needed to investigate the mechanism by which this potential benefit may operate.

Although the data the HRS collects on dental-related issues is limited, it has provided significant insight on oral health care utilization. The data is limited by its inability to speak to oral health-related outcomes or whether the reported dental visits translated into adherence to treatment and oral care recommendations. In addition, we are unable to account for changes in dental attendance due to patients transitioning to edentulous status.

Cancer treatment negatively affects oral health, and guidelines recommend an oral health evaluation and education to be a part of routine cancer treatment and survivorship care. This study provides concerning evidence that, contrary to guidelines, dental visits decrease precipitously following a new cancer diagnosis, a finding with implications for patient quality of life and overall health. Further study in this area is needed to understand how barriers to getting in the door of a dental office translate into oral health outcomes.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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