

# Predictors of engagement in post-discharge quitline counseling among hospitalized smokers

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Received: January 3, 2018 / Accepted: July 13, 2018 / Published online: July 19, 2018  
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**Abstract** Quitlines provide evidence-based tobacco treatment and multiple calls yield higher quit rates. This study aimed to identify subgroups of smokers with greater quitline engagement following referral during hospitalization. Data were from a randomized clinical trial assessing the effectiveness of fax referral (referral faxed to proactive quitline) versus warm handoff (patient connected to quitline at bedside) ( $n = 1054$ ). Classification and regression trees analyses evaluated individual and treatment/health system-related variables and their interactions. Among all participants, warm handoff, higher ratings of the tobacco treatment care transition, and being older predicted completing more quitline calls. Among patients enrolled in the quitline, higher transition of care ratings, being older, and use of cessation medication post-discharge predicted completing more calls. Three of the four factors influencing engagement were characteristics of treatment within the hospital (quality of tobacco treatment care transition and referral method) and therapy (use of cessation medica-

tions), suggesting potential targets to increase quitline engagement post-discharge.

**Keywords** Hospitalization · Tobacco quitlines · Engagement · Smoking cessation · Transitional care

## Introduction

Quitting smoking reduces risks of smoking-related disease and improves prognoses for existing diseases (Critchley & Capewell, 2003; Parsons et al., 2010). Hospitals are excellent settings for identifying and treating tobacco users, and numerous national guidelines encourage hospitals to actively treat tobacco dependence (Fiore et al., 2012). Tobacco treatment provided in the hospital is effective when treatment continues for at least one month post-discharge (Rigotti et al., 2012). Most effective hospital trials employed telephone counseling, provided by dedicated study staff, to provide post-discharge follow up (Rigotti et al., 2012). Hospitals seeking to translate current evidence into practice should consider referral to tobacco quitlines. In the United States, publicly-funded proactive quitlines are widely accessible to interested smokers in all states, and services are offered free of charge (North American Quitline Consortium, 2011).

Post-discharge treatment via quitlines has the potential for widespread adoption and excellent intervention “reach.” Previous studies show promise for engaging patients in tobacco treatment (Leuthard et al., 2015; Warner et al., 2016). However, the best-laid hospital plans for outpatient care often fail to be implemented post-discharge (Coleman & Berenson, 2004), and this also may be true for post-discharge quitline counseling. Challenges to delivery of post-discharge tobacco treatment for hospitalized

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Each author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

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smokers include low follow-up rates among referred smokers (Faseru et al., 2011; Ylioja et al., 2017). An initiative conducted in one state in the US found that 41% of hospital-based fax referrals resulted in quitline enrollment (Leuthard et al., 2015). Of these, only half (52%) participated in more than one counseling session (Leuthard et al., 2015). Participating in multiple quitline counseling sessions has been shown to yield higher quit rates than single-session counseling (Bernstein et al., 2016; Zbikowski et al., 2008; Zhu et al., 1996).

Fax referral, where patients' contact information is sent to the quitline and smokers receive proactive calls from the quitline, is more effective at getting smokers to enroll in quitline services than simply asking patients to call (Bentz et al., 2006). Warm handoff has the potential to further improve quitline utilization because patients are directly connected to the quitline at bedside to enroll and participate in a counseling call during their hospitalization. Two recent studies have examined the effectiveness of referring hospitalized smokers to the quitline using warm handoff and fax for tobacco treatment post-discharge (Richter et al., 2016; Warner et al., 2016). Richter et al. (2016) was the only study to randomly assign study participants to either warm handoff versus fax referral. This study found that warm handoff resulted in greater quitline enrollment rates compared to fax referral (99.6 vs. 59.6%). However, there was no difference between study arms for the number of post-discharge counseling calls completed. These findings from the trial suggest that factors beyond referral method may influence patients' acceptance and completion of proactive calls from the quitline after leaving the hospital, when tobacco treatment follow-up is needed to promote cessation and prevent relapse.

No studies, to date, have examined whether specific characteristics of hospital patients, or of hospital care, are associated with uptake and engagement in counseling following hospital-based quitline referral. The World Health Organization (WHO) developed a framework for factors associated with adherence and applied it to smoking cessation interventions. Factors that may impact adherence were classified using five dimensions: (1) social and economic factors (e.g., race, age, education); (2) health care team and health-system related factors (e.g., patient-provider relationship, access to smoking cessation pharmacotherapy); (3) condition-related factors relating to the severity of the illness (e.g., cigarettes per day, nicotine dependence); (4) therapy-related factors (e.g., characteristics of the treatment, side effects, withdrawal symptoms); and (5) patient-related factors (e.g., motivation or intention to quit, self-efficacy) (Sabaté, 2003).

Several factors have been associated with engagement in proactive quitline counseling among outpatient quitline enrollees. Receiving nicotine replacement therapy (NRT)

(An et al., 2006; Burns et al., 2012; Hollis et al., 2007), older age (Burns et al., 2012; Zbikowski et al., 2011), being married (Zbikowski et al., 2011), lower education (Skov-Ettrup et al., 2014), and previous use of NRT (Zbikowski et al., 2011) were associated with completing more counseling calls. The variables in these studies, however, accounted for only 5–9% of the variance in counseling engagement, indicating that the research to-date provides an incomplete explanation of participation in quitline counseling for smoking cessation. Importantly, these previous studies did not examine health care team and health-system factors that could impact quitline engagement.

In order to address the gap in the literature related to health care team and health-system factors that may impact quitline utilization, the current study examined whether factors from each of the five dimensions (social and economic, health care team and health-system, condition-related, therapy-related, and patient-related factors) impacted quitline call completion. We included the following health care team and health-system related factors: type of health insurance, emergency room admission versus planned admission and patients' perception of the quality of the care transition from inpatient tobacco treatment predicted engagement. Transitional care is defined as the steps taken to coordinate care as patients transfer between types of care within one setting or between settings (Bentz et al., 2006).

Determining predictors of quitline engagement (e.g. rates of post-discharge enrollment and call completion), can inform hospital policies and facilitate the development of individualized tobacco treatment plans. The current study builds on previous research conducted with outpatients by extending this research to the inpatient setting and examining whether treatment and systems-related factors impact engagement in post-discharge quitline counseling. We conducted a secondary analysis of the data from a randomized clinical trial that evaluated the relative effectiveness of warm handoff versus fax referral of hospitalized smokers for post-discharge tobacco treatment (Richter et al., 2016).

The aim of this study was to identify factors associated with quitline enrollment and engagement in counseling among hospitalized smokers referred to the quitline while in the hospital using the WHO framework for factors associated with adherence (Sabaté, 2003). The application of this framework to smoking cessation interventions primarily centered on evidence from studies assessing adherence to nicotine replacement therapies (Sabaté, 2003). Further, although we expected that warm handoff to the quitline would emerge as an important predictor due to significant differences in quitline enrollment by treatment arm in the parent clinical trial (Richter et al., 2016), we aimed to identify other important factors that best characterized subgroups of participants who had greater engage-

ment in quitline counseling after discharge. Therefore, we used an exploratory approach—classification and regression trees (CART). CART analyses have been used to identify subgroups who are at risk for poor adherence to pharmacological and behavioral interventions and screening recommendations (Calvocoressi et al., 2005; Dominick et al., 2015; Gaalema et al., 2017). Advantages of CART analysis are that it simultaneously considers all predictor variables and their possible interactions to identify mutually exclusive, homogenous subgroups (Lemon et al., 2003). Rather than only identifying individual predictors of adherence, CART analyses evaluate all combinations of predictors to identify sets of characteristics that best characterize adherence/non-adherence among the population of interest. The models identified in these analyses will indicate subgroups of participants who are most likely to engage in quitline counseling from a range of individual, treatment, and health-system related factors based on the WHO framework of predictors of adherence to smoking cessation interventions (Sabaté, 2003).

## Methods

Study data were obtained from Enhancing Quitline Utilization among In-Patients (EQUIP), a randomized clinical trial that assessed the effectiveness of fax referral to the state quitline versus warm handoff (direct referral connecting the patient to the quitline in their hospital room) for post-discharge follow-up (Richter et al., 2016). The trial began in 2011 and six-month follow-up was completed in 2014.

## Procedures

Approval for the procedures was obtained from the researchers' Human Subjects Committees. Inpatients from two large, Midwest hospitals were recruited into the study by dedicated hospital tobacco treatment staff using the same protocol. Study tobacco treatment counselors identified smokers through provider orders for tobacco treatment, self-referral, and from a list of hospitalized smokers generated from the electronic medical record (EMR) across hospital units. Study tobacco treatment counselors screened patients for eligibility, obtained informed consent from each participant, and administered a baseline survey. Eligible participants were current cigarette smokers randomized to one of two study arms: fax referral (usual care) or warm handoff. Participants were contacted to complete follow-up phone surveys at 1 and 6 months post-randomization. A more detailed description of study eligibility criteria and procedures are provided elsewhere (Richter et al., 2012, 2016).

Participants in the fax referral group received the hospital's standard inpatient tobacco use treatment at the time of eligibility screening, randomization, and baseline data collection. On the day of discharge, patients' referral forms were faxed to the quitline. Tobacco use counseling included assessing smoking history and readiness to quit, discussing withdrawal, medication education, developing a quit plan, and discussing and arranging for in-hospital smoking cessation medications and post-discharge prescriptions. Participants in the warm handoff group received abbreviated tobacco use counseling at the time of eligibility screening, randomization, and baseline data collection. Because participants in the warm handoff arm would be connected to a quitline counselor for an initial session, counseling provided by study tobacco treatment counselors focused only on assessing withdrawal symptoms and the need for smoking cessation medication. The counselor then called the quitline and transferred the call to the participant for enrollment and an initial counseling session. Participants received a brief check back visit from the hospital counselor on the same day that included discussing interest in obtaining a smoking cessation medication prescription on discharge.

Kansas quitline services are provided by Optum through a contract with the Kansas Department of Health and Environment (KDHE). Quitline services include 5 proactive counseling calls and additional "ad hoc" calls available for participants placing calls to the quitline to talk to a quit coach.

## Measures

### *Demographic and socioeconomic characteristics*

Participants' age and gender were obtained through the EMR. During the baseline survey, participants reported their race and ethnicity, whether they lived with other smokers, and their highest level of education.

Health care team and health-system related factors. Type of insurance (private, Medicare, Medicaid, Veterans Affairs (VA) health system, and self-pay/no insurance), mode of admission (emergency room—yes/no), and length of stay were retrieved from the EMR. Perceptions of the quality of their tobacco treatment care transitions from hospital to post-discharge quitline counseling were assessed using items adapted from the Care Transition Measure (CTM) (Coleman et al., 2005) at 1-month follow up. The adapted scale consisted of 7 items reflecting three of the four CTM-15 domains: critical understanding, management preparation, and care plan (e.g., Before I left the hospital, my hospital counselor [quit coach] and I agreed about clear smoking cessation goals and how these goals would be reached; When I left the hospital, I had a plan for

how I was going to quit smoking [or stay quit]) (see Appendix). Each item was rated from 1 “strongly disagree” to 4 “strongly agree” and the scale score was determined by summing the items. Cronbach’s alpha for the adapted 7-item measure was 0.82.

#### *Condition-related factors*

At baseline, participants were asked to report the average number of cigarettes they smoked on the days they smoked, the number of days smoked in the past 30 days, and whether they used other forms of tobacco in the past 30 days. Nicotine dependence was assessed using the Heaviness of Smoking Index (HSI) (de Leon et al., 2003). Participants were also screened for alcohol abuse using the Alcohol Use Disorder Identification Test (AUDIT-C) (Bush et al., 1998) and for depression using the Patient Health Questionnaire 2 (PHQ-2) (Kroenke et al., 2003). Primary and secondary discharge diagnoses and procedure codes were obtained from the EMR. Diagnosis-related group (DRG) codes were used to identify whether participants underwent cardiac or cerebrovascular surgery due to their association with higher quit rates among smokers (Shi & Warner, 2010; United Kingdom Small Aneurysm Trial Participants, 2002).

#### *Therapy-related factors*

At one-month follow-up, participants were asked whether they had used nicotine replacement medications (including nicotine patch, gum, inhaler, spray, or lozenge), varenicline, or bupropion since their discharge from the hospital. The following data were obtained from the EMR: in-hospital use of cessation medications, and whether a prescription for cessation medications was provided at discharge. We included method of referral to the tobacco quitline (warm handoff vs. fax referral) as a therapy-related factor.

#### *Patient-related factors*

At baseline, patients rated their confidence to quit or stay quit on a 5-point scale with 5 indicating the highest level of confidence. Participants also reported their intent to quit or stay quit after hospital discharge. We included confidence to quit as a measure of self-efficacy and intent to quit as a measure of participants’ level of motivation to quit.

#### *Quitline enrollment and engagement*

Quitline enrollment and call data were obtained from Optum. Calls that were at least 5 min in duration were

identified as intervention calls; we did not include calls that were < 5 min because the quitline provider, Optum, determined that these were unlikely to include smoking cessation intervention based on reviews of counselor notes and recordings (e.g., the participant may not have been available to complete a counseling call). The number of proactive (outgoing to the participant) and ad hoc (incoming from the participant) intervention calls completed by each participant were summed to provide the total number of quitline calls completed.

#### **Statistical analyses**

Frequencies and percentages were calculated for categorical variables and means and standard deviations for continuous variables. Chi square tests (for categorical variables) and *t*-tests (for continuous variables) were conducted to determine whether there were statistically significant differences between participants who enrolled in the quitline compared to participants who did not enroll.

Classification and regression trees (CART) analyses were used to identify subgroups of participants that completed higher numbers of quitline counseling calls. We chose CART analysis because it evaluates all potential predictors as well as their interactions to determine the subgroup characteristics that best predict adherence. An advantage of CART analysis is that it creates decision trees that are easy for clinicians to follow and that are easy to interpret (Adams & Leveson, 2012; Merkle & Shaffer, 2011). Similar to linear regression analyses, CART uses conditional means but does not assume that these associations are linear (King & Resick, 2014). CART analyses can also be useful in identifying interactions that researchers did not anticipate as it examines all possible interactions among predictors (King & Resick, 2014). Therefore, these analyses have been applied to describing subgroups of individuals who benefit or fail to benefit from interventions (Loh et al., 2012; Piper et al., 2011; Swan et al., 2004, 2008).

CART is able to compensate for missing predictor values (King & Resick, 2014), thus imputation was not needed to handle missing data. The *rpart* package in R includes observations on the condition that there are values for the dependent variable and one or more independent variables (Therneau & Atkinson, 2018). First, impurity indices and probabilities are calculated over variables with complete data for the predictors, then adjusted. If there are participants with missing data on a splitting variable, *rpart* uses “surrogate variables”, i.e., the partitioning algorithm is applied to predict the split points in the splitting variable using other independent variables. Split points are then rank ordered based on the optimal split and the calculated misclassification error.

Using CART, groups of patients are split into subgroups based on their values on a given predictor. “Good” predictors are identified based on their ability to optimally divide groups of patients into smaller groups. CART algorithms evaluate all possible cut-points across all predictors at each split (Merkle & Shaffer, 2011). The best “split” on a given predictor produces the largest group difference (i.e., the smallest within-group sum of squares); thus, each split creates more homogenous subgroups (King & Resick, 2014). These splits produce a decision tree representing all subgroups created by partitioning the data. The CART algorithm generates several decision trees that are then “pruned” to remove branches with only trivial differences between subgroups, reducing the probability of Type I error (Venkatasubramaniam et al., 2017). CART then compares the trees in terms of their ability to predict data via *k*-fold cross-validation (splitting the sample into training and validation sets) to select the decision tree with the best prediction.

We conducted two CART analyses using *rpart* package in R (R Core Team, 2015; Therneau et al., 2015) to determine predictors of engagement among (1) all patients referred to the quitline, and (2) among patients who enrolled in the quitline. In the parent clinical trial, almost all participants assigned to warm handoff successfully enrolled (99.6%) and 59.6% of participants assigned to fax referral were enrolled (Richter et al., 2016). The purpose of this CART was to identify other potential predictors and moderators of enrollment and engagement in the quitline among participants in the clinical trial beyond referral method. We assumed that differences in engagement were likely due to the large and significant difference in enrollment by treatment assignment (Richter et al., 2016). Hence, to determine predictors of engagement regardless of referral route, we included only people who enrolled in the quitline in the second CART analysis. Our second analysis examined predictors of engagement in quitline calls among those enrolled in the quitline program. Each CART analysis predicting number of calls completed included the following: demographic and socioeconomic characteristics, health-system related factors, condition-related factors, therapy-related factors, and patient-related factors.

In addition, we assessed the associations of the predictors selected by the CART analysis with the number of quitline calls completed using two multiple linear regression models. The multiple linear regression models cross-validated the CART findings and in addition provided the amount of variance in quitline call completion accounted for by the predictors identified in the CART analysis.

## Results

### Participant characteristics

A total of 1,054 smokers enrolled in the parent clinical trial. Overall, participants had an average age of 49.9 years (SD = 12.9), 55.1% were female, 68.2% were White, 24.9% were African American, and 6.9% reported another race (see Table 1). A small proportion of the sample reported being Latino (5.9%). Approximately half of the participants lived with another smoker (49.6%). The majority of participants were daily smokers (72.0%) and the average number of cigarettes per day was 15.7 (SD = 11.0). Comparing participants who enrolled to those who did not enroll, two statistically significant differences were found: participants who enrolled had higher ratings of the quality of care transition (CTM scores of 21.26 (SD = 4.1) vs. 20.46 (SD = 4.5),  $P = 0.033$ ) and participants who enrolled in the quitline were more likely to have been referred via warm handoff (62.6%) than via fax referral (37.4%,  $P < 0.001$ ).

### CART analysis for the entire sample

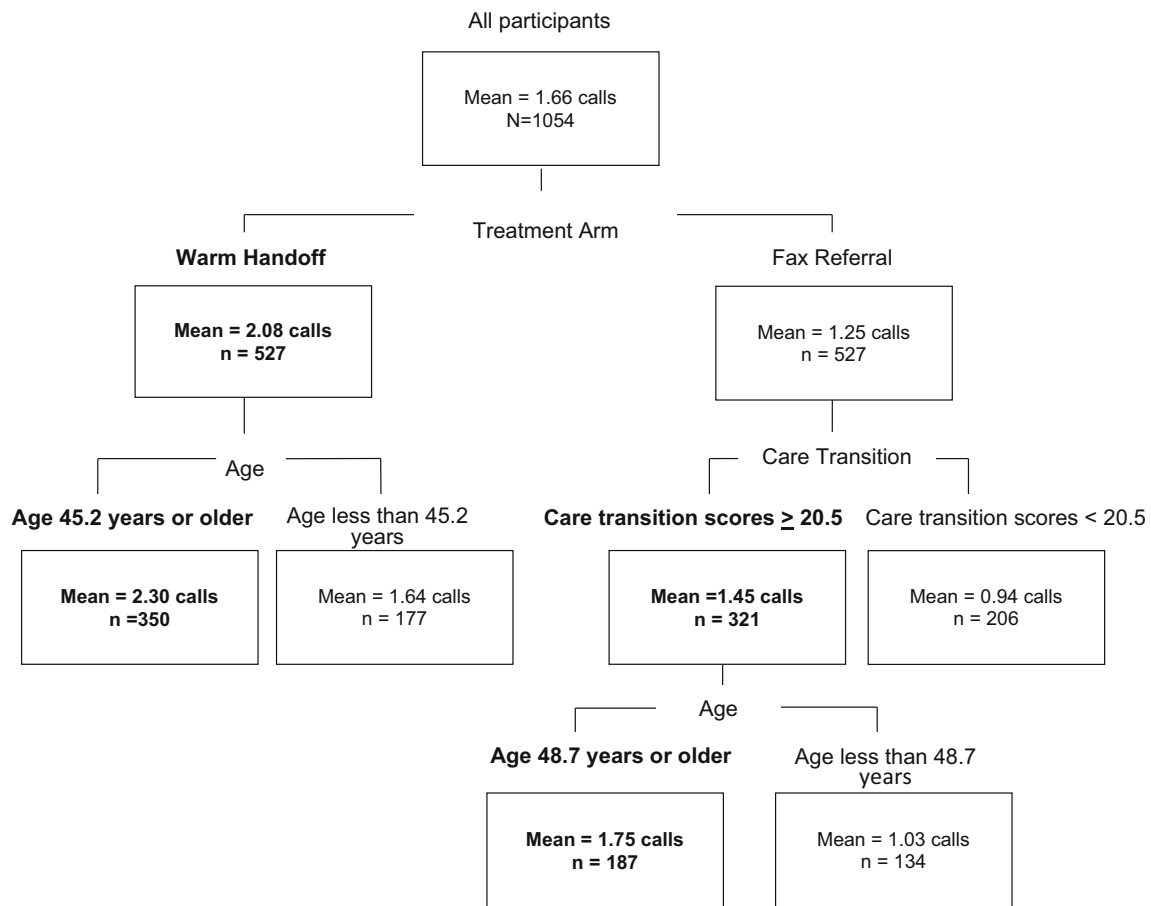
Among all patients referred to the quitline, patients who were referred via warm handoff, those who perceived the hospital as providing a good care transition, and who were 45.2 years or older had greater engagement in quitline counseling. The mean number of calls completed was 1.66 (median = 1). Three of the 21 potential predictor variables remained in the decision tree (see Fig. 1). The optimal split across all participants in the study was by treatment group (i.e., warm handoff vs. fax referral) indicating that the method for quitline referral had the greatest impact on completion of quitline calls. Warm handoff participants completed more calls (mean of 2.08 calls) than fax-referred participants (mean of 1.25 calls).

There were additional splits within each treatment group showing that other factors predicted whether participants were engaged in quitline counseling. Within the fax group, participants’ ratings of care transitions (CTM) produced the most profound split in number of calls completed. Participants who reported experiencing better care transitions for tobacco treatment (as indicated by higher CTM scores [ $> 20.5$ ]) completed more calls (mean = 1.45 calls) and participants with lower ratings of the care transitions ( $< 20.5$ ) completed fewer calls (mean = 0.94 calls). The fax-referred group was further subdivided with a second split by age among participants with high CTM scores. Older participants ( $\geq 48.7$  years) completed more calls than younger participants ( $< 48.7$  years; 1.75 vs. 1.03 calls, respectively). Within the warm handoff group, only

**Table 1** Participant characteristics for total sample and by quitline enrollment

Variables	Total sample (n = 1054)	Enrolled in quitline (n = 839)	Not enrolled in quitline (n = 215)	P value*
<i>Demographics</i>				
Age, mean (SD)	49.9 (12.9)	49.89 (12.9%)	49.92 (13.1%)	0.975
Female, no. (%)	581 (55.1%)	466 (55.5%)	115 (53.5%)	0.589
Race				0.958
White, no. (%)	719 (68.2%)	571 (68.1%)	148 (68.8%)	
African American, no. (%)	262 (24.9%)	209 (24.9%)	53 (24.7%)	
Other, no. (%)	73 (6.9%)	59 (7%)	14 (6.5%)	
Latino, no. (%)	62 (5.9%)	48 (5.7%)	14 (6.6%)	0.646
Live with other smoker, no. (%)*	523 (49.6%)	428 (51%)	95 (44.2%)	0.074
<i>Socioeconomic factors</i>				
Education < High school, no. (%)	231 (21.9%)	186 (22.2%)	45 (20.9%)	0.640
<i>Health system factors</i>				
Primary insurance				
Medicaid, no. (%)	314 (29.8%)	289 (34.4%)	66 (30.7%)	
Medicare, no. (%)	355 (33.7%)	247 (29.4%)	67 (31.2%)	
Private, no. (%)	306 (29.0%)	241 (28.7%)	65 (30.2%)	
VA, no. (%)	12 (1.1%)	11 (1.3%)	1 (0.5%)	
Self-pay/none, no. (%)	67 (6.4%)	51 (6.1%)	16 (7.4%)	0.628
Care Transitions, mean (SD)	21.1 (4.2)	21.26 (4.1)	20.46 (4.5)	<b>0.033</b>
Possible Range 7–28				
Length of stay (hours), mean (SD)	134. (133.1)	132.0 (132.2)	146.0 (136.3)	0.180
Emergency room admission, no. (%)	630 (59.8%)	495 (59%)	135 (62.8%)	0.312
<i>Condition-related factors</i>				
Cigarettes per day (CPD), mean (SD)	15.7 (11.1)	15.6 (11.2)	15.9 (10.7)	0.692
Daily smoking (> 25/30 days), no. (%)	759 (72.0%)	611 (72.8%)	148 (68.8%)	0.245
Heavy smoking index (HSI) > 4, no. (%)	347 (32.9%)	271 (32.3%)	76 (35.3%)	0.396
Use other forms of tobacco, no. (%)	82 (7.8%)	66 (7.9%)	16 (7.4%)	0.836
Reason for admission				
Circulatory system, no. (%)	261 (24.8%)	210 (25%)	51 (23.7%)	
Respiratory system, no. (%)	121 (11.48%)	104 (12.4%)	17 (7.9%)	
Neoplasms, no. (%)	50 (4.74%)	38 (4.5%)	12 (5.6%)	
Mental Disorders, no. (%)	22 (2.09%)	17 (2.0%)	5 (2.3%)	
Other, no. (%)	600 (56.9%)	470 (56%)	130 (60.5%)	
Cardiac and cerebrovascular surgery, no. (%)	121 (11.5%)	102 (12.2%)	19 (8.8%)	0.173
Alcohol Use Disorder (AUDIT-C), no. (%)*	323 (30.7%)	263 (31.3%)	60 (27.9%)	0.329
Possible Depression (PHQ-2), no. (%)	566 (53.8%)	451(53.8%)	115 (53.7%)	0.983
<i>Therapy-related factors</i>				
Used cessation medication in hospital, no. (%)	342 (36.5%)	283 (37%)	59 (34.3%)	0.500
Medications prescribed at discharge, no. (%)	324 (31.0%)	264 (31.7%)	60 (28.3%)	0.346
Self-reported use of medication post-discharge, no. (%)	264 (28.2%)	216 (28.3%)	48 (27.7%)	0.874
Referral method				
Fax, no. (%)	527 (50.0%)	314 (37.4%)	213 (99.1%)	
Warm hand-off, no. (%)	527 (50.0%)	525 (62.6%)	2 (0.9%)	<b>&lt;0.001</b>
<i>Patient-related factors</i>				
Confidence to quit/stay quit (possible range 1– 5), mean (SD)	3.8 (1.1)	3.80 (1.1)	3.77 (1.1)	0.686
Intent to quit/stay quit				
Plan to stay quit at discharge, no. (%)	464 (44.0%)	369 (44.0%)	95 (44.2%)	0.957
Plan to try to quit at discharge, no. (%)	590 (56.0%)	470 (56.0%)	120 (55.8%)	

\*P values reported for differences between participants who enrolled in quitline vs. those who did not enroll. Boldface indicates statistical significance ( $P < 0.05$ )



**Fig. 1** Classification and regression tree for all participants referred to quitline (n = 1054) identifying subgroups of patients with greater adherence to quitline counseling

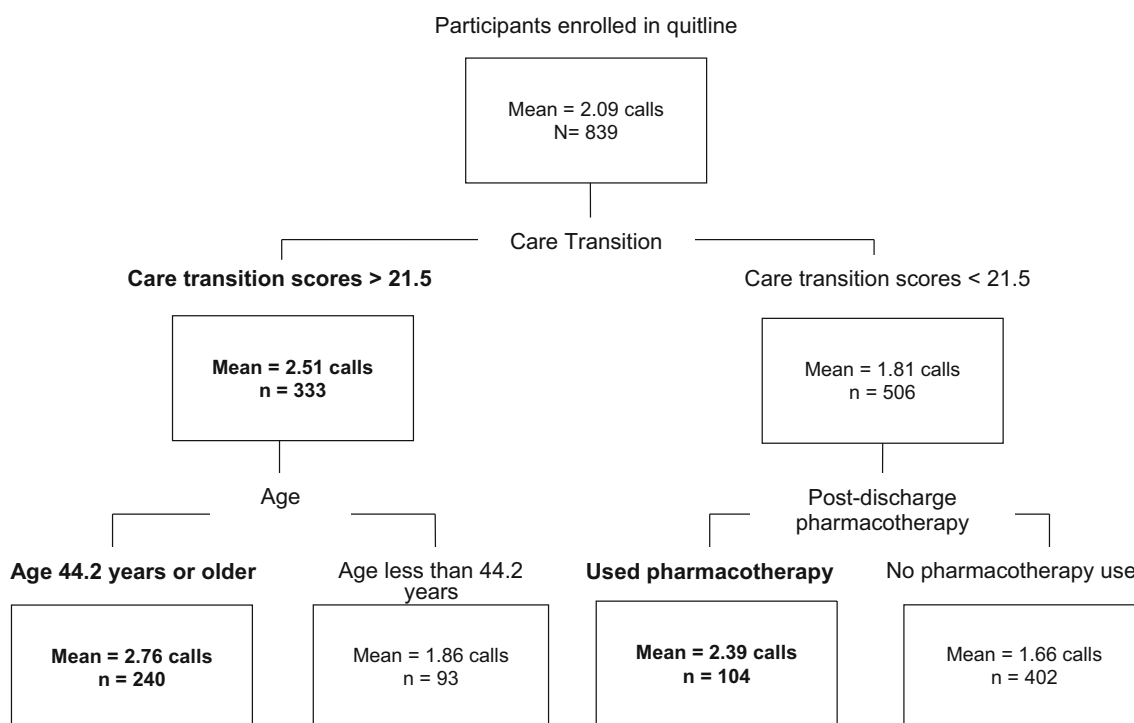
one variable, age, further subdivided this group. Participants were split by age such that older participants ( $\geq 45.2$  years) completed more calls (mean = 2.30) than younger participants ( $< 45.2$  years; mean = 1.64).

**CART analysis for participants who enrolled in the quitline**

Among patients who enrolled in the quitline (n = 839), those who perceived that the hospital provided a good care transition, who were 44 years or older, and who used cessation medication post-discharge were more engaged in quitline counseling. This decision tree also included 3 of 21 possible variables (see Fig. 2). The first split was created by care transitions (CTM) scores indicating that participants’ ratings of the care transition was the primary driver of differences in number of calls completed. Participants who gave higher ratings of the care transition (CTM scores  $\geq 21.5$ ) completed more calls (mean = 2.51 calls) than participants who gave lower ratings (CTM scores  $< 21.5$ ; mean = 1.81 calls). Two additional splits further subdivided participants. Among participants who provided

high ratings on the CTM, age was an important predictor of number of calls completed, with older participants ( $\geq 44.2$  years) completing more calls than younger participants ( $< 44.2$  years; 2.76 vs. 1.86 calls). For participants with lower CTM scores, post-discharge cessation medication was associated with completing more quitline calls compared to participants who did not use cessation medication post-discharge (2.39 vs. 1.66 calls).

We cross-validated the findings from the CART using multiple linear regression. In the model including all participants, age, referral method, and CTM scores all had standardized slopes in the same order as indicated by the CART analysis (Table 2). The  $R^2$  for this model was 0.108, indicating that these three variables accounted for approximately 11% of the variance in the number of calls completed. Among participants who enrolled in the quitline, age, CTM scores, and use of smoking cessation medications post-discharge showed slopes in the same order predicted by the CART analysis (Table 2). This model accounted for approximately 7% of the variance in the number of quitline calls completed ( $R^2 = 0.070$ ).



**Fig. 2** Classification and regression tree for participants enrolled in the quitline ( $n = 839$ ) identifying subgroups of patients with greater adherence to quitline counseling

## Discussion

Warm handoff referral to the quitline, higher perceived quality of the tobacco treatment care transition, and older age predicted greater enrollment and engagement in quitline counseling after hospitalization. Among smokers who enrolled in the quitline, higher quality of tobacco treatment care transition, use of smoking cessation medication post-discharge, and older age predicted greater completion of post-discharge quitline counseling calls. Age was the only demographic variable that distinguished between participants who were more versus less engaged in quitline counseling. Therefore, high quality care transitions, warm handoff, and use of medication post-discharge were the three mutable variables that may help inpatients connect to, and better engage in quitline counseling. Among patients who enrolled in the quitline, referral method did not emerge as an important predictor but the perceived quality of the tobacco treatment care transition remained a key factor in quitline engagement.

These findings are novel and suggest that post-discharge counseling engagement is in great part associated with variables that can be modified, that is, are related to systems of care and not to patients' individual characteristics. Regardless of the referral method to the quitline, which was the focus of the parent clinical trial, the perceived quality of care transitions influenced engagement in quit-

**Table 2** Multiple linear regression models for number of calls completed

Variables	Beta coefficient	P value
<i>Model 1 including all study participants<sup>a</sup></i>		
Age	0.130	<0.001
Care transitions	0.189	<0.001
Referral method	0.244	<0.001
<i>Model 2 including only participants enrolled in the quitline<sup>b</sup></i>		
Age	0.147	<0.001
Care transitions	0.183	<0.001
Post-discharge cessation pharmacotherapy	0.104	0.003

Due to listwise deletion for missing values, the sample size for Model 1<sup>a</sup> was 932 and the sample size for Model 2<sup>b</sup> was 760

line counseling. Aspects of post-discharge care that affect perceptions of the care transition include the transfer of information among providers, preparing the patients and caregivers for post-discharge care, support for self-management of the condition, and empowering the patient to discuss their preferences during treatment planning (Coleman et al., 2002). Applied to tobacco treatment, this may include attending to how patients are referred (e.g., warm handoff or fax referral), providing brief tobacco treatment that gives patients opportunities to select treatment options (e.g., medication), prepares patients for follow-up calls



from the quitline, and ensuring that patients understand what support is available to them post-discharge.

Similar to findings from studies of quitline uptake (An et al., 2006; Hollis et al., 2007), recently hospitalized smokers who received smoking cessation medications after hospital discharge were more engaged with the quitline. Importantly, smoking cessation medications were not a specific component of the parent clinical trial. In this trial, neither the hospital nor the quitline directly provided smoking cessation medications for post-discharge use. Inpatient counselors did, however, encourage patients to use cessation medications by educating patients regarding the types of cessation medications available, encouraging patients to request a script to fill at discharge, and recording patient preferences for post-discharge cessation medications in the hospital EMR. Patients may have received and filled prescriptions at discharge or at follow-up appointments or purchased over-the-counter cessation medications. Medications may have enhanced smokers' ability to engage in quitline counseling and the smoking cessation process by reducing withdrawal and craving. Medications may be particularly important for patients who perceived their tobacco treatment care transition as being lower quality.

Older participants completed more counseling calls. Given our sample, older patients may have experienced more tobacco-related illness or exacerbation of other conditions. Alternatively, they may be more apt to use telephone counseling as a modality for treatment. Quitlines are rapidly offering more treatment modalities such as web-based counseling and text-messaging to engage a broader smoker demographic.

### Limitations

Limitations of this study include that the results are from only two hospitals. Importantly, patients were recruited across all hospital units, thereby increasing the generalizability of the findings. A second limitation is that, although we sought to include a more comprehensive taxonomy of factors associated with adherence to smoking cessation intervention related to patient, treatment, and health care system characteristics, our list of variables was not exhaustive; for example, we did not include other tobacco use. Given that the predictors identified using CART only accounted for 7–11% of the variance in quitline engagement, there may be other important factors related to counseling engagement that we did not account for. Importantly, our analyses focused on participant and hospital tobacco treatment characteristics but did not directly measure perceptions or preferences related to the quitline counseling process. A third limitation is that participants' perceptions of the transitions in care for tobacco treatment

were assessed during the one-month follow-up survey and their experiences with the quitline could have influenced their recall of the care transition; however, this time frame was within the range of previous care transition measure validation studies (Coleman et al., 2002, 2005). Finally, use of smoking cessation medication was also assessed at one month follow-up; given this timeframe, an alternate explanation for our findings is that quitline coaches encouraged enrollees to use medications resulting in increased medication use among participants engaged in quitline counseling.

### Conclusions

Health care policy encourages evidence-based tobacco treatment for all hospitalized smokers. Effective treatment for hospitalized smokers includes post-discharge follow-up, and quitlines are a widely available and cost-effective option for post-discharge care. We found that younger participants completed fewer counseling calls, therefore, future research should investigate potentially targeting approaches for post-discharge tobacco treatment by age. We found that three of the four factors that affected patients' engagement in quitline counseling were health system and therapy-related factors. This suggests that more attention should be given to the referral process and the care transition, including access to pharmacotherapy post-discharge, in order to increase quitline utilization and, in turn, quit rates.

**Acknowledgements** This work was supported by the National Heart, Lung, and Blood Institute [Grant Number U01 HL105232-01]. The clinical trials registration number is NCT01305928. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, and Blood Institute or the National Institutes of Health. The study sponsor had no role in study design; collection, analysis, or interpretation of data; writing the report; or the decision to submit the report for publication.

### Compliance with ethical standards

**Conflict of interests** Taneisha S. Scheuermann, Kristopher J. Preacher, Beatriz H. Carlini, Terry Bush, Brooke Magnusson, Niaman Nazir and Kimber P. Richter have no institutional or corporate affiliations that conflict with this study, and no financial disclosures were reported by the authors of this paper.

**Human and animal rights and Informed consent** All study procedures were approved by institutional review boards at both hospitals (KUMC HSC 123456; SV HSC IRB00008059) and all participants provided consent. The preliminary findings of this study were presented at the Annual National Conference of the Association for Medical Education and Research in Substance Abuse (AMERSA) in November 2014. Informed consent was obtained from all patients for being included in the study.

## Appendix

Response scale: Strongly Disagree = 1; Disagree = 2; Agree = 3; Strongly Agree = 4; Don't Know/Not Applicable = Missing

1. Before I left the hospital my hospital counselor [quit coach] and I agreed about clear smoking cessation goals for me and how these would be reached.
2. Before I left the hospital my hospital counselor [quit coach] and I discussed what types of smoking cessation medication (if any) I could use when I left the hospital.
3. When I left the hospital, I understood how to obtain quit smoking medications.
4. When I left the hospital, I had all the information I needed to be able to quit smoking [stay quit].
5. When I left the hospital, I had a plan for how I was going to quit smoking [stay quit].
6. When I left the hospital, I was confident that I knew what to do to quit [stay quit].
7. When I left the hospital, I had a schedule of appointments set up with a quit smoking counselor I needed to complete within the next several weeks.

## References

- Adams, S. T., & Leveson, S. H. (2012). Clinical prediction rules. *BMJ*, *344*, d8312. <https://doi.org/10.1136/bmj.d8312>
- An, L. C., Schillo, B. A., Kavanaugh, A. M., Lachter, R. B., Luxenberg, M. G., Wendling, A. H., et al. (2006). Increased reach and effectiveness of a statewide tobacco quitline after the addition of access to free nicotine replacement therapy. *Tobacco Control*, *15*, 286–293. <https://doi.org/10.1136/tc.2005.014555>
- Bentz, C. J., Bayley, K. B., Bonin, K. E., Fleming, L., Hollis, J. F., & McAfee, T. (2006). The feasibility of connecting physician offices to a state-level tobacco quit line. *American Journal of Preventive Medicine*, *30*, 31–37. <https://doi.org/10.1016/j.amepre.2005.08.043>
- Bernstein, S. L., Weiss, J.-M., Toll, B., & Zbikowski, S. M. (2016). Association between utilization of quitline services and probability of tobacco abstinence in low-income smokers. *Journal of Substance Abuse Treatment*, *71*, 58–62. <https://doi.org/10.1016/j.jsat.2016.08.014>
- Burns, E. K., Levinson, A. H., & Deaton, E. A. (2012). Factors in nonadherence to quitline services: Smoker characteristics explain little. *Health Education and Behavior*, *39*, 596–602. <https://doi.org/10.1177/1090198111425186>
- Bush, K., Kivlahan, D. R., McDonnell, M. B., Fihn, S. D., & Bradley, K. A. (1998). The AUDIT alcohol consumption questions (AUDIT-C): An effective brief screening test for problem drinking. *Archives of Internal Medicine*, *158*, 1789–1795. <https://doi.org/10.1001/archinte.158.16.1789>
- Calvocoressi, L., Stolar, M., Kasl, S. V., Claus, E. B., & Jones, B. A. (2005). Applying recursive partitioning to a prospective study of factors associated with adherence to mammography screening guidelines. *American Journal of Epidemiology*, *162*, 1215–1224. <https://doi.org/10.1093/aje/kwi337>
- Coleman, E. A., & Berenson, R. A. (2004). Lost in transition: Challenges and opportunities for improving the quality of transitional care. *Annals of Internal Medicine*, *141*, 533–539.
- Coleman, E. A., Mahoney, E., & Parry, C. (2005). Assessing the quality of preparation for posthospital care from the patient's perspective: The care transitions measure. *Medical Care*, *43*, 246–255.
- Coleman, E. A., Smith, J. D., Frank, J. C., Eilertsen, T. B., Thiare, J. N., & Kramer, A. M. (2002). Development and testing of a measure designed to assess the quality of care transitions. *International Journal of Integrated Care*, *2*, e02.
- Critchley, J. A., & Capewell, S. (2003). Mortality risk reduction associated with smoking cessation in patients with coronary heart disease: A systematic review. *JAMA*, *290*, 86–97. <https://doi.org/10.1001/jama.290.1.86>
- de Leon, J., Diaz, F. J., Becona, E., Gurpegui, M., Jurado, D., & Gonzalez-Pinto, A. (2003). Exploring brief measures of nicotine dependence for epidemiological surveys. *Addictive Behaviors*, *28*, 1481–1486.
- Dominick, G. M., Papas, M. A., Rogers, M. L., & Rakowski, W. (2015). Classification tree analysis to examine influences on colorectal cancer screening. *Cancer Causes and Control*, *26*, 443–454. <https://doi.org/10.1007/s10552-015-0523-6>
- Faseru, B., Turner, M., Casey, G., Ruder, C., Befort, C. A., Ellerbeck, E. F., et al. (2011). Evaluation of a hospital based tobacco treatment service: Outcomes and lessons learned. *Journal of Hospital Medicine*, *6*, 211–218. <https://doi.org/10.1002/jhm.835>
- Fiore, M. C., Goplerud, E., & Schroeder, S. A. (2012). The joint commission's new tobacco-cessation measures—will hospitals do the right thing? *New England Journal of Medicine*, *366*, 1172–1174.
- Gaalema, D. E., Savage, P. D., Rengo, J. L., Cutler, A. Y., Elliott, R. J., Priest, J. S., et al. (2017). Patient characteristics predictive of cardiac rehabilitation adherence. *Journal of Cardiopulmonary Rehabilitation and Prevention*, *37*, 103–110. <https://doi.org/10.1097/hcr.0000000000000225>
- Hollis, J. F., McAfee, T. A., Fellows, J. L., Zbikowski, S. M., Stark, M., & Riedlinger, K. (2007). The effectiveness and cost effectiveness of telephone counselling and the nicotine patch in a state tobacco quitline. *Tobacco Control*, *16*, i53–i59. <https://doi.org/10.1136/tc.2006.019794>
- King, M. W., & Resick, P. A. (2014). Data mining in psychological treatment research: A primer on classification and regression trees. *Journal of Consulting and Clinical Psychology*, *82*, 895–905. <https://doi.org/10.1037/a0035886>
- Kroenke, K., Spitzer, R. L., & Williams, J. B. (2003). The patient health questionnaire-2: Validity of a two-item depression screener. *Medical Care*, *41*, 1284–1292. <https://doi.org/10.1097/01.MLR.0000093487.78664.3C>
- Lemon, S. C., Roy, J., Clark, M. A., Friedmann, P. D., & Rakowski, W. (2003). Classification and regression tree analysis in public health: Methodological review and comparison with logistic regression. *Annals of Behavioral Medicine*, *26*, 172–181. [https://doi.org/10.1207/s15324796abm2603\\_02](https://doi.org/10.1207/s15324796abm2603_02)
- Leuthard, J. L., Beebe, L. A., Halstead, L., Olson, K. D., & Roysdon, J. W. (2015). Increased evidence-based tobacco treatment through Oklahoma hospital system changes. *American Journal of Preventive Medicine*, *48*, S65–S70. <https://doi.org/10.1016/j.amepre.2014.09.017>
- Loh, W.-Y., Piper, M. E., Schlam, T. R., Fiore, M. C., Smith, S. S., Jorenby, D. E., et al. (2012). Should all smokers use combination smoking cessation pharmacotherapy? Using novel analytic methods to detect differential treatment effects over 8 weeks of pharmacotherapy. *Nicotine & Tobacco Research*, *14*, 131–141. <https://doi.org/10.1093/ntr/ntr147>

- Merkle, E. C., & Shaffer, V. A. (2011). Binary recursive partitioning: background, methods, and application to psychology. *British Journal of Mathematical and Statistical Psychology*, *64*, 161–181. <https://doi.org/10.1348/000711010X503129>
- North American Quitline Consortium. (2011). *Moving quitlines forward: North American quitline consortium 2008/2009 annual report*. Retrieved from Oakland, CA.
- Parsons, A., Daley, A., Begh, R., & Aveyard, P. (2010). Influence of smoking cessation after diagnosis of early stage lung cancer on prognosis: Systematic review of observational studies with meta-analysis. *BMJ*, *340*, b5569. <https://doi.org/10.1136/bmj.b5569>
- Piper, M. E., Loh, W. Y., Smith, S. S., Japuntich, S. J., & Baker, T. B. (2011). Using decision tree analysis to identify risk factors for relapse to smoking. *Substance Use and Misuse*, *46*, 492–510. <https://doi.org/10.3109/10826081003682222>
- R Core Team. (2015). R: A language and environment for statistical computing. Vienna, Austria: R Foundation. Retrieved from <https://www.r-project.org/>
- Richter, K. P., Faseru, B., Mussulman, L. M., Ellerbeck, E. F., Shireman, T. I., Hunt, J. J., et al. (2012). Using “warm handoffs” to link hospitalized smokers with tobacco treatment after discharge: study protocol of a randomized controlled trial. *Trials*, *13*, 127.
- Richter, K. P., Faseru, B., Shireman, T. I., Mussulman, L. M., Nazir, N., Bush, T., et al. (2016). Warm handoff versus fax referral for linking hospitalized smokers to quitlines. *American Journal of Preventive Medicine*, *51*, 587–596. <https://doi.org/10.1016/j.amepre.2016.04.006>
- Rigotti, N. A., Clair, C., Munafo, M. R., & Stead, L. F. (2012). Interventions for smoking cessation in hospitalized patients. *Cochrane Database Systematic Review*, *5*, Cd001837. <https://doi.org/10.1002/14651858.CD001837.pub3>
- Sabaté, E. (Ed.). (2003). *Adherence to long-term therapies: Evidence for action*. Geneva, Switzerland: World Health Organization.
- Shi, Y., & Warner, D. O. (2010). Surgery as a teachable moment for smoking cessation. *Anesthesiology*, *112*, 102–107. <https://doi.org/10.1097/ALN.0b013e3181c61cf9>
- Skov-Ettrup, L. S., Dalum, P., Ekholm, O., & Tolstrup, J. S. (2014). Reach and uptake of Internet- and phone-based smoking cessation interventions: results from a randomized controlled trial. *Preventive Medicine*, *62*, 38–43. <https://doi.org/10.1016/j.ypmed.2014.01.020>
- Swan, G. E., Jack, L. M., Javitz, H. S., McAfee, T., & McClure, J. B. (2008). Predictors of 12-month outcome in smokers who received bupropion sustained-release for smoking cessation. *CNS Drugs*, *22*, 239–256.
- Swan, G. E., Javitz, H. S., Jack, L. M., Curry, S. J., & McAfee, T. (2004). Heterogeneity in 12 month outcome among female and male smokers. *Addiction*, *99*, 237–250.
- Therneau, T., & Atkinson, E. (2018). An introduction to recursive partitioning using the RPART routines. Division of Biostatistics, Mayo Foundation. Retrieved from <https://cran.r-project.org/web/packages/rpart/vignettes/longintro.pdf>
- Therneau, T., Atkinson, B., & Ripley, B. (2015). rpart: Recursive partitioning and regression trees, 2014 (Version 4.1-8). Retrieved from Available at CRAN. R-project.org/package = rpart
- United Kingdom Small Aneurysm Trial Participants. (2002). Long-term outcomes of immediate repair compared with surveillance of small abdominal aortic aneurysms. *New England Journal of Medicine*, *346*, 1445–1452. <https://doi.org/10.1056/NEJMoa013527>
- Venkatasubramaniam, A., Wolfson, J., Mitchell, N., Barnes, T., JaKa, M., & French, S. (2017). Decision trees in epidemiological research. *Emerging Themes in Epidemiology*, *14*, 11. <https://doi.org/10.1186/s12982-017-0064-4>
- Warner, D. O., Nolan, M. B., Kadimpati, S., Burke, M. V., Hanson, A. C., & Schroeder, D. R. (2016). Quitline tobacco interventions in hospitalized patients: A randomized trial. *American Journal of Preventive Medicine*. <https://doi.org/10.1016/j.amepre.2016.03.005>
- Ylioja, T., Reddy, V., Ambrosino, R., Davis, E. M., Douaihy, A., Slovenkay, K., et al. (2017). Using bioinformatics to treat hospitalized smokers: Successes and challenges of a tobacco treatment service. *The Joint Commission Journal on Quality and Patient Safety*, *43*, 621–632. <https://doi.org/10.1016/j.jcjq.2017.06.010>
- Zbikowski, S. M., Hapgood, J., Smucker Barnwell, S., & McAfee, T. (2008). Phone and web-based tobacco cessation treatment: Real-world utilization patterns and outcomes for 11,000 tobacco users. *Journal of Medical Internet Research*, *10*, e41. <https://doi.org/10.2196/jmir.999>
- Zbikowski, S. M., Jack, L. M., McClure, J. B., Deprey, M., Javitz, H. S., McAfee, T. A., et al. (2011). Utilization of services in a randomized trial testing phone- and web-based interventions for smoking cessation. *Nicotine & Tobacco Research*, *13*, 319–327. <https://doi.org/10.1093/ntr/ntq257>
- Zhu, S. H., Stretch, V., Balabanis, M., Rosbrook, B., Sadler, G., & Pierce, J. P. (1996). Telephone counseling for smoking cessation: Effects of single-session and multiple-session interventions. *Journal of Consulting and Clinical Psychology*, *64*, 202–211.