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The Impact of Tobacco-Specific Health Knowledge on Smoking Cessation

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A.B.
Washington University in St. Louis
2012

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Abstract

The Impact of Tobacco-Specific Health Knowledge on Smoking Cessation

By Joshua I. Berry

Objectives: This study aims to understand the relationships between tobacco-specific health knowledge, evidence-based smoking cessation pharmacotherapy use, and self-reported smoking cessation status at the end of a smoking cessation program.

Methods: A prospective observational cohort study was conducted using data from the Courage to Quit (CTQ) program, a community health intervention based in Chicago, Illinois (n=1062). Logistic regression models were computed to determine which of three different tobacco knowledge measures (mean knowledge score before a brief education session, mean knowledge score after this education session, and the difference in these two scores) were associated with increased odds of smoking cessation as measured at the end of the program. These models were also examined to determine whether the use of cessation pharmacotherapy during the CTQ program was a mediator or confounder of the relationship between the tobacco knowledge measures and smoking cessation.

Results: A one-point increase out of seven points in the mean posttest knowledge score was most strongly correlated with successful smoking cessation, but this association is not statistically significant (OR = 1.13, CI = [0.99, 1.30]). Cessation medication use was significantly correlated with successful cessation in models evaluating two of the three knowledge measures (OR = 1.17, CI = [1.00, 2.92] in the knowledge pretest score model), but was not a confounder or mediator in any of these models.

Conclusions: There is insufficient evidence to conclude that tobacco-specific health knowledge is positively associated with successful smoking cessation, or that cessation pharmacotherapy use mediates or confounds this relationship. These findings stand somewhat in contrast to earlier research that suggests that higher health literacy is associated with increased odds of smoking cessation. Future research should use a comprehensive and better validated measure of tobacco knowledge to better evaluate the potential association between tobacco knowledge and smoking cessation.

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Background and Review of Literature

Cigarette Smoking and Cessation in the United States

Despite steadily decreasing adult smoking rates, tobacco use remains the single greatest preventable cause of death in the United States, with approximately 480,000 American deaths attributable to smoking each year (1). Approximately 17.8% of adults currently smoke cigarettes, with significant disparities in smoking rates based on sociodemographic factors such as gender, race/ethnicity, poverty status, and age. However, educational attainment remains the most differentiating of all tobacco-related determinants. Only 5.6% of Americans with a postgraduate degree reported smoking cigarettes in 2013, compared to 41.4% of adults with a General Educational Development (GED) certification, a sevenfold difference between these groups. As a comparison, the differences in cigarette smoking rates by poverty status (17.0% cigarette smoking rate among adults living above the poverty line versus 27.9% of adults living below the poverty line) or by race (as high as 26.8% for multiracial individuals and as low as 9.6% for those who identify as Asian) are not as extreme (2). Greater investments in research and targeted interventions are needed to eliminate disparities in smoking rates and the resulting tobacco-related deaths and diseases.

Although most American smokers indicate that they want to quit, and a majority of smokers do try to quit, these attempts are usually unsuccessful, and disparities exist with regards to the desire to quit smoking and success in these quit attempts (3,4). According to data from the 2010 National Health Interview Survey (NHIS), 68.8% of smoking adults reported being interested in quitting. This contrasts with the 73.9% of smoking adults with a GED who reported being interested in quitting. This represents the

highest figure for any individual demographic group, and it corresponds to the demographic group with the highest smoking rates in the United States. The NHIS also found that 52.4% of American adults tried to quit smoking at least once in the previous year, though this does not necessarily translate into greater success, as cessation rates also vary by demographic group. The average success rate in smoking cessation over the previous year among American smokers was 6.2%, and those with lesser educational attainment were less likely to be successful in their quit attempts (4). Altogether, these data demonstrate that while smokers with poor educational attainment are interested in quitting smoking, they have greater difficulties in doing so successfully.

One potential barrier in getting more people to quit smoking successfully might be in encouraging those who want to quit to adopt evidence-based methods in their quit attempts (3,5). The U.S. Department of Health and Human Services (HHS) recognizes several types of evidence-based methods that improve one's likelihood of quitting smoking, which can be divided into non-medicine treatments and cessation medications (i.e., pharmacotherapies). These non-medicine treatments include:

(1) Brief advice (ten minutes or less) from one's doctor on how to quit smoking

(2) Cessation counseling one-on-one, as part of a group, or over the phone

(3) Targeted behavioral therapies (e.g., problem solving training)

(4) Treatments with greater intensity in terms of frequency and/or length of the treatment

(5) Cessation programs delivered on one's mobile phone (3,5)

Because trying these interventions requires varying investments of one's time and/or money, it follows that not all Americans have equal access to the behavioral therapies that can help them quit smoking.

HHS also recognizes that different cessation medications are effective in increasing one's chances of quitting smoking. These pharmacotherapies are typically divided into two categories: nicotine replacement therapies (NRTs), which provide a quitting smoker with the addictive drug nicotine in a carefully dosed manner with the eventual goal of ending nicotine dependence entirely, and prescription non-nicotine medications, which address nicotine addiction in the brain through other physiological pathways. Most NRTs are available over the counter and include nicotine patches, gums, and lozenges. Prescription NRTs exist as well, including nicotine inhalers, nasal sprays, and other forms of the nicotine patch. There are currently two approved non-nicotine prescription medications available on the market, which are bupropion SR (brand name Zyban®) and varenicline tartrate (brand name Chantix®). Utilizing both counseling treatments and cessation pharmacotherapies simultaneously is more effective than using just one form of treatment on its own, so this strategy represents an ideal way to improve one's chances of quitting smoking (5).

Despite the availability of many evidence-based methods to improve one's chances of quitting smoking, 68.3% of adults who tried to quit smoking did so without utilizing any such methods, and those who did not graduate from high school reported being the least likely educational attainment group to use these methods. Other demographic groups demonstrate more extreme disparities in this regard, including race/ethnicity (with Hispanics and non-Hispanic African-Americans using evidence-

based methods less than other groups) and age, with the youngest American adults least likely to use pharmacotherapies (4). There is a clear disconnect in wanting to quit smoking and utilizing the best methods to accomplish this difficult task. Two related concepts in the public health literature, health literacy and health knowledge, help shed light on this disconnect.

Health Literacy

Health literacy is typically defined as "The degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" (6-8). Nutbeam expands on this understanding to define three different types of health literacy, with each different type of literacy requiring greater social and cognitive capability: basic/functional literacy, communicative/interactive literacy, and critical literacy (9). The prevalence and consequences of poor health literacy have also been explored in the literature in recent years. About 25% of American adults (44 million) are impacted by low health literacy and approximately 50 million more have limited literacy skills (6,10).

Applying these findings in a tobacco cessation context, one can synthesize that many adults in the United States potentially struggle with comprehending information about smoking cessation and acting on that information properly. Those with poor educational attainment, which puts one at risk for low health literacy, might face an especially great struggle in understanding and applying knowledge about smoking cessation (6,9,11). This could explain why those with lesser educational attainment smoke at such high rates. In addition to being an issue among less educated Americans, health literacy is also common among those who are not native English speakers, those

with lower incomes, and racial and ethnic minorities. Many of these segments of American society, most notably those with low incomes and with low educational attainment, are also more likely to be cigarette smokers, further underscoring the potential connection between poor health literacy and smoking (12).

The aforementioned definitions of health literacy imply that the term has both individual and social components, and different frameworks that have been created to better understand health literacy allude to these components. For example, an Institute of Medicine framework identifies three main intervention points for changing health literacy: the greater society/culture, the healthcare system, and the education system. This framework proposes that all three of these systems impact health literacy and ultimately contribute to health outcomes and healthcare costs (11). Consequently, one could hypothesize that an intervention that targets at least one of these three areas to improve health literacy would go on to improve health outcomes in diseases linked to health literacy. In another framework, health literacy is proposed as a health promotion outcome, which exists as a consequence of health promotion but directly impacts both intermediate health outcomes and health and social outcomes. In this model, tobacco use is listed as a healthy lifestyle measure in the intermediate health outcome level, confirming the potential for the operationalization of health literacy in a tobacco control context as supported in the current theoretical frameworks for health literacy (9).

Research also suggests that poor health literacy is possibly responsible for deficiencies in translating public health communication into population behavioral changes, as well as poorer health outcomes (6, 13-15). Seventy-five percent of those with at least one chronic condition in the United States have limited health literacy, and

obstacles in managing chronic conditions means that poor health literacy costs as much as $73 billion in healthcare costs every year (6). Since health warnings (e.g., on tobacco product packages and print advertisements) and anti-smoking media campaigns are a major part of national efforts to continue to reduce cigarette smoking in the United States, it is imperative to know when these initiatives might be less effective for those with poor health literacy. Comparable research in the area of cancer prevention has demonstrated links between poor health literacy and worse cancer knowledge and cancer prevention efforts, lending some credibility to this line of thinking, but research specifically exploring the association between health literacy and cancer outcomes is lacking (16-18).

Health Knowledge

Health knowledge does not have as well established a definition in the literature, but it might be best understood as a specific component of health literacy. For example, the common definition of health literacy previously mentioned, centers around "health information" and being able to retain it and apply it to better one's health, which is certainly related to health knowledge (6). In addition, an HHS fact sheet lists health knowledge among the "individual and systemic factors" that together make up health literacy, suggesting that the two concepts are closely tied to one another (12). The fact sheet goes on to state that health literacy has an impact on one's ability to engage in self-care and chronic-disease management, which includes one's efforts to quit smoking and perhaps use evidence-based therapies to make quit attempts more successful (12). These theoretical associations are confirmed by research which has found that those with poor health literacy have lower comprehension of health education materials and have less knowledge of the chronic diseases that effect them (19,20). While the terms health

knowledge and health literacy should not be used interchangeably, it should be acknowledged that the terms are highly related and thus research on health literacy does shed some light on the health knowledge in a general sense.

Apart from being conceptually related to health literacy, health knowledge is also a component of health behavioral theories that have been applied to the topic of smoking cessation. Behavioral capability, a key construct in Bandura's Social Cognitive Theory (SCT), hypothesizes that both knowledge and skills comprise one's ability to successfully perform a behavior (21). Smoking cessation presents a clear example of behavioral capability because of how difficult it is to quit smoking and how adhering to evidence-based cessation therapies successfully can increase one's likelihood of quitting (21,22). Not on Tobacco, a cessation program developed by the American Lung Association for adolescents aged 14-19, features a curriculum based on SCT but primarily utilizes constructs other than behavioral capability (23,24). In addition, Prochaska's Transtheoretical Model (TTM), which was developed with smoking cessation explicitly in mind and is frequently cited in the smoking cessation literature, includes consciousness raising, one of ten processes of change. Consciousness raising posits that increasing awareness through relevant information can help to encourage behavioral change (25). Thus there is reason to hypothesize in the context of both of these theories that health beliefs and knowledge in a tobacco-specific context might be causally related to one's ability to quit smoking.

Even though TTM is used in many health behavior interventions, not much is known about how the construct of consciousness raising can be operationalized in a successful theory-based intervention (25,26). However, there is research to suggest that

health education, as part of a relationship with healthcare providers and/or behavioral counselors, can improve health outcomes and reduce healthcare costs through health behavior changes in the context of chronic disease self-management for a variety of conditions (27). Specific examples include research on a sample of African-American adolescents with asthma and a review of fibromyalgia syndrome interventions (28,29). Even though cigarette smoking may not itself be a chronic disease, it is a long-term struggle that often leads to tremendous mortality and morbidity burdens from chronic disease (1,3). This research thus supports the notion that educating smokers on the risks of cigarette smoking, and how one can quit, can lead to improved cessation outcomes. This is consistent with the scientific consensus that receiving advice from one's doctor on how and why to quit smoking improves one's changes of quitting smoking (4).

State of the Research

There are currently no peer-reviewed studies that explore tobacco-specific health knowledge specifically within the context of smoking cessation, and very few that address health literacy and smoking cessation. However, there are many reasons that a better understanding of the relationship between tobacco health knowledge and cigarette smoking could improve health outcomes. First, cigarette smoking is a major preventable death and disease burden that is a driver of many health disparities, so addressing this vital public health issue will help many Americans, especially the underserved (1-3). Second, there is great opportunity for interventions pertaining to health education and health literacy to encourage successful smoking cessation and lower smoking prevalence rates. This is because many of the evidence-based smoking cessation practices recommended by HHS relate to health education, such as behavioral counseling and

receiving brief (ten minutes or less) instruction from a physician on the health benefits of quitting smoking (5). Third, there is a thorough theoretical understanding of health literacy that demonstrates how improvements in health literacy would lead to reduced smoking rates and thus improved health outcomes (9,10).

The peer-reviewed articles on these topics provide a background on how health knowledge or health literacy might be related to successful smoking cessation in a sample of Americans. For example, a cross-sectional study involving 402 low-socioeconomic status American male and female smokers found that that low health literacy was significantly correlated with well-established barriers to successful smoking cessation such as nicotine dependence and intentions to quit smoking or cut back. Since this was a cross-sectional study, the outcome of smoking cessation could not be measured, as all study participants were cigarette smokers at the time of analysis. Nonetheless, these results represent the first evidence in the literature that low health literacy is indeed associated with successful smoking cessation, but more research is needed to understand this association in greater detail (30).

Recently, researchers have been trying to better understand the association between smoking cessation and health literacy and/or health knowledge (31-34). One study examining data from the International Tobacco Control survey (n=9,058 covering the United States, Canada, the United Kingdom, and Australia) indicated that in the United States, 93.7% of respondents could identify that smoking causes lung cancer in smokers, but only 36.1% could correctly state that smoking causes impotence (31). An especially relevant study conducted in Houston, Texas (n=200) found that participants with low health literacy were significantly more likely than those with high health

literacy to relapse during the course of a smoking cessation program, even after controlling for related factors such as socioeconomic status and race/ethnicity (32). This study is the first to investigate the relationship between health literacy and smoking cessation prospectively in the context of a cessation intervention.

Other research has also demonstrated that knowledge of the harms of smoking is associated with increased likelihood of long-term cessation (33,34) and that brief educational interventions can have a positive impact on one's tobacco knowledge, though this knowledge can decline over time (35,36). Such educational interventions focused on tobacco cessation do not need to be elaborate, since leaflets and educational sessions of fewer than ten minutes given by one's doctor have been demonstrated to help smokers quit (5,36). Even though these two pieces of the puzzle are well understood, there is still a need for research that prospectively examines tobacco knowledge to determine how it relates to successful smoking cessation.

In summary, health literacy is a well-researched topic in a general sense, but studies that assess interventions on improving poor health literacy and any resulting positive health consequences, with regards to smoking cessation or other health outcomes, are relatively lacking. Health knowledge is not nearly as well defined, but the two concepts are strongly related to one another and health knowledge can probably be understood as one of several components of health literacy. There are relatively few studies that describe health knowledge or health literacy specifically in the context of tobacco use or tobacco cessation in the United States, and most of those studies do not explore the association between these concepts and one's likelihood to quit smoking. These studies also do not consider the impacts that health knowledge might have on the

use of evidence-based cessation methods, which have the potential to increase one's likelihood of successfully quitting smoking. This study fills a gap in the literature on this topic by assessing the association between tobacco-specific health knowledge and successful smoking cessation prospectively. In addition, this study considers whether or not cessation pharmacotherapy use is a mediator or a confounder of this association.

Methods

Study Design

This is a prospective observational cohort study of data obtained from the Courage to Quit (CTQ) smoking cessation program based out of Chicago, Illinois, and administered by the Respiratory Health Association (RHA) in partnership with the University of Chicago (37). The exposure of interest in this study is tobacco-specific health knowledge, and the outcome of interest is successful smoking cessation by the end of the program.

Program Description

CTQ is an ongoing evidence-based community smoking cessation intervention developed in 2008 by Dr. Andrea King, a University of Chicago professor in the Department of Psychiatry and Behavioral Neuroscience. CTQ was established to provide affordable and effective smoking cessation services to citizens throughout the metro-Chicago area. There are two different program formats that are offered: one that meets for an hour each week for three weeks and one that meets an hour each week for six weeks. Both programs take a week off between the second to last session and the last session to help empower participants to take charge of their own smoking cessation without the assistance of the program. A few minor changes have been made to the long program in order to correct errors, improve formatting, and make it easier to administer, so there exist an original and revised versions of the six-week program (only the revised version is currently administered). No changes were made to the curriculum itself. This accounts for a total of three iterations of the CTQ program, two of which are currently administered (the short and the revised long programs).

The CTQ program is delivered to the community by Chicago-area adults certified by RHA after learning about smoking cessation science, policy, and program facilitation techniques at a one-day training. These certified program leaders are typically health professionals affiliated with a hospital, a clinic, or a community non-profit organization, or they may be employees of RHA. After individuals are trained to be CTQ program leaders, they are highly autonomous in how they deliver the program. Trained CTQ leaders are permitted to recruit any smoking adults who are interested in participating in the program, by whichever recruitment methods those individuals wish to employ. Recruitment methods may include a posting on the CTQ website, referring clients from one's work, referrals from clients' friends and family, and other means of outreach (37). The leaders are also free to choose which iteration(s) of the program (the three-session and/or the six-session formats) to administer to their recruited participants based on their capacity to deliver the program and the perceived needs of their prospective clients. To help encourage participation by individuals of all income levels, RHA asks that program leaders make CTQ available for free or for a nominal cost (typically not exceeding $35 for the full program), though pricing decisions are ultimately made by each individual CTQ leader (37). CTQ participant notebooks for both iterations of the program are available in English, Spanish, and Polish.

A recent peer-reviewed article assessing the effectiveness of the Courage to Quit program found that the program was effective in leading to smoking cessation at the conclusion of the program, defined as self-reported seven day abstinence from cigarettes (38). Results from this study determined that participants of the six-week intervention program were more likely to quit than those who enrolled in the three-week program.

Additionally, participants significantly improved on average on each of the eight beliefs and knowledge Likert scale items after the brief education intervention administered in the first session of each program (38).

Study Population

The initial study sample includes all 1,789 adult Chicago-area smokers who enrolled in the CTQ program according to survey data that RHA received from the trained peer leaders administering the program. Participants were included in this analysis if they completed all program surveys and attended all training sessions. A total of 701 participants failed to meet these criteria, leaving 1,088 participants. An additional 26 participants were excluded because they self-reported no cigarette smoking in the seven days prior to enrolling in the program. Smoking cessation is not possible when one reports no smoking at the beginning of the program. These participants likely enrolled in the program because they felt that they might be at risk of starting to smoke again. The final sample for this study included 1,062 (59% of all participants in the dataset) Chicago-area individuals who completed the program and self-reported smoking cigarettes in the week leading up to CTQ enrollment. These participants were as young as 18 years of age (the minimum age of enrollment) and as old as 82.

Data Collection Instruments

Data were collected from study participants in the form of four surveys over the course of all CTQ program iterations. These paper surveys were filled out individually by participants with the program leader present to answer any questions participants might have had about survey questions. The first survey was completed at the beginning of the first session and collected demographic information and data on tobacco use at baseline

and past cessation attempts. The second survey was completed during the first session and included five knowledge-related Likert scale items assessing their agreement or disagreement with statements that either directly reflect or contradict evidence-based positions on smoking cessation (the initial iteration of the CTQ program, administered to 190 participants in this study sample, included three additional items that were removed in order to make these pretests and posttests easier to complete). Following a brief ten-minute education session that aims to correct common myths about tobacco cessation and increase knowledge of evidence-based methods, participants completed this same knowledge instrument as a posttest during the first session of each program iteration, constituting the third survey. Finally, all participants completed a fourth and final posttest survey during the final program session to self-report their smoking habits at the conclusion of the program and provide written feedback on the program. Data from these four surveys are included in this study analysis.

Data Measures

This study aims to assess the relationship between tobacco-specific health knowledge and one's odds of quitting smoking over the course of the three- or six-week cessation program. Tobacco knowledge is measured in CTQ surveys by four different Likert scale items included in both the knowledge pretest and posttest (see Appendix), each of which recorded an integer score between one and seven for each participant. These prompts are as follows:

> (1) There are several stop smoking medications such as nicotine replacement (patch, gum, etc), Zyban®, or Chantix® that have been shown by scientific evidence to improve one's chances of quitting smoking.

(2) Behavioral counseling, in a group or individual setting, has been shown by scientific evidence to improve one's chances of quitting smoking.

(3) There are several alternative techniques such as lasers, hypnosis, acupuncture, and herbs that have been shown by scientific evidence to improve one's chances of quitting smoking.

(4) Nicotine replacement products (patch, gum, lozenge, etc.) can cause cancer.

The three items that appeared only in the earlier iteration of the six-session program were not utilized for the tobacco knowledge measure, and one of the remaining five questions was excluded because it asks about CTQ participation rules and not tobacco-related health beliefs. In these questions, a score of one indicates that the participant strongly disagrees with the prompt, while a score of seven indicates that the participant strongly agrees. For some items, a "strongly disagree" response represents a perfect agreement with evidence-based methods, while for other items a response of "strongly agree" would be consistent with the scientific consensus (3,5). Thus reverse coding was employed for prompts three and four above so that a score of seven represents perfect consensus with researchers and evidence-based methods, and a score of one represents perfect disagreement with the scientific consensus. This allows for mean scores of all four questions to be calculated based on this scale, and these scores can be calculated in three different ways from the pretest and posttest items:

(1) Mean pretest score: This measures participants' tobacco-related knowledge before participating in the CTQ program.

(2) Mean posttest score: This measures participants' tobacco-related knowledge after the brief education session during the first meeting of the CTQ program.

(3) Mean difference between pretest and posttest scores: This measures the change in tobacco knowledge resulting from the brief education session.

Each of these three measures were considered separately in different logistic regression models to see which definition of tobacco-related knowledge is most strongly associated with smoking cessation over the course of the program. The pretest score best measures participants' tobacco knowledge before enrolling in the CTQ program, so these preconceptions might be correlated with smoking cessation most strongly even if the education session is successful in improving tobacco knowledge. Posttest score captures participants' tobacco knowledge after the education session, which might be the most accurate measure of one's tobacco knowledge as they attempt to quit smoking during the CTQ program. However, there are concerns that increases in tobacco knowledge might not be sustainable (35). Finally, the relationship between score difference and smoking cessation is of great interest because this will determine whether the effectiveness of the CTQ education session itself, independently of pretest or posttest tobacco knowledge, leads to increased odds of smoking cessation.

Cigarette smoking, the primary outcome variable of interest, was measured at baseline and at the conclusion of the CTQ program by a survey item that asked about seven-day smoking prevalence. Participants classified their smoking frequency into one of five categories: seven days in the previous week, five or six days in the previous week, three or four days in the previous week, one or two days in the previous week, or zero days in the previous week. Thus smoking cessation is defined as having smoked cigarettes for zero days in the previous week as self-reported on the last meeting of the CTQ program, with all other response options indicating that a participant did not quit

smoking. Thus smoking cessation, the outcome of interest in this study, will be defined in this dichotomous manner so that standard logistic regression models can be fit using CTQ data.

Several additional measures obtained from the first session survey were examined as covariates. These covariates are: the use of tobacco cessation medication, participant age at the time of enrollment in CTQ, employment status, educational attainment, marital status, race, ethnicity, living with a cigarette smoker at home, and the number of days one smoked cigarettes the week before enrollment. These variables were included in part based on the hypothesized causal relationships between potential covariates as described in a directed acyclic graph (DAG) (see Figure 1). The DAG hypothesizes how covariates measured by the CTQ surveys might causally relate to each other and to the exposure and outcome of interest. Most importantly, the DAG outlines how the use of evidence-based smoking cessation pharmacotherapies while enrolled in the CTQ program might mediate the association between tobacco knowledge and successful cessation.

Analysis Plan

First, descriptive statistics were calculated for each variable included in the study. Next, mean scores of for pretest tobacco knowledge, posttest tobacco knowledge, and the mean difference between these two measures were calculated for each of the four included items. The means for each of these items were then averaged to arrive at the three tobacco knowledge measures described above. A series of two-sided matched pairs T-tests were performed to see if the mean scores for each knowledge item individually, and the mean of all four knowledge items, differed significantly between pretest and posttest. Third, all variables included in the study were assessed for possible collinearity

in two different ways. Bivariate correlation coefficients were calculated for every pair of variables included in this study, and then a matrix of conditional indexes and variance decomposition proportions (VDPs) was computed corresponding to each of the six logistic regression models described in the next step. Correlation coefficients greater than 0.7 (or less than -0.7) were defined as a strong bivariate correlation that could indicate a possible collinearity issue. Collinearity problems were defined as two or more non-intercept variables with corresponding VDPs greater than 0.5 with an associated conditional index greater than 30. For each of the models described below, removal of variables preceded sequentially, moving from largest to smallest remaining conditional indices, until all identified collinearity problems were resolved.

Finally, six different logistic regression models were run to obtain estimates of effect for all variables of interest with respect to successful smoking cessation. Two different logistic regression models were computed for each of the three different tobacco knowledge measures, which included all aforementioned covariates as potential confounders. One model for each measure included the use of evidence-based NRTs or prescription medications, and one model excluded it in order to consider that variable as a potential confounder or mediator of the relationship between tobacco knowledge and smoking cessation. Reduced versions of all models, which included only statistically significant covariates, were then determined by a backwards elimination procedure. First, likelihood ratio tests were performed to sequentially eliminate other covariates one at a time based on a lack of statistically significant improvement of the models' goodness of fit associated with the inclusion of each covariate. Once these models that included only significant covariates were determined, change-in-estimate confounding (the 10% rule)

and different effect estimate precisions of the exposure variables were taken into account, considering all possible additionally reduced models simultaneously, to arrive at final models. These final models were used to calculate odds ratios (ORs) and 95% confidence intervals (CIs) for predictor variables of interest and any covariates that remained in the model.

The general form of the described logistic regression equations is presented below:

$$\textit{logit}\ P(X) = \alpha + \Sigma\ \beta_i E_i + \Sigma\ \gamma_i V_i$$ where:

X = Self-reported seven-day abstinence from cigarette smoking at the end of the program (0 = no cessation, 1 = successful cessation)

α = Intercept

β_i = Exposure parameter coefficient(s)

E_i = Exposure parameter(s)

γ_i = Covariate parameter coefficient(s)

V_i = Covariate parameter(s)

For all logistic regression models in which pharmacotherapy use was determined to be a mediator of the relationship between tobacco knowledge and smoking cessation based on correlation coefficients and odds ratios, direct and indirect effect estimates for each of the tobacco knowledge measures were calculated. The odds ratios corresponding to tobacco knowledge score for each model that does not include pharmacotherapy use in

the model represent the direct estimate of effect for knowledge score (the E→O pathway on the DAG, see Figure 1). The odds ratios for pharmacotherapy use in the models that include this predictor represent the C→O path of the DAG, since all odds ratios in these models are with respect to outcome variable of smoking cessation. The first odd ratio can be divided by the second to obtain the effect estimate of pharmacotherapy use as it relates to tobacco-specific health knowledge (represented by E→C on the DAG).

Results

Table 1 presents basic descriptive statistics for CTQ participants' demographic information. The mean age of CTQ participants is 46.7 years old. Close to half of participants identified as black or African American (48.4%), while many of the remaining participants identified as white/Caucasian (34.5%). Considered independently of racial identity, 17.9% of participants also indicated having Hispanic ethnicity. CTQ participants are also quite varied with respect to educational attainment. Most respondents indicated that they did not complete a college degree, with 28.6% reporting that they went to college but did not graduate, 26.3% of participants responding that they completed high school or obtained a GED, and 19.0% of participants having not completed high school. The majority of CTQ participants reported working full-time (40.3%) while others indicated that they work part-time or occasionally (13.9%). With regards to marital status, most of the participants described themselves as single (43.2%) or married or living as married (30.8%).

Table 2 presents basic descriptive statistics with regards to participants' smoking frequency, pharmacotherapy use, and CTQ program information. During the first survey session, 82.1% of participants self-reported that they smoked cigarettes on each of the prior seven days, with the remaining 17.9% smoking at least one or two days, but no more than five or six days in the prior week. During the final program session, 29.3% of CTQ participants reported smoking cigarettes on none of the prior seven days, meaning that they self-reported week-long cigarette abstinence at the end of the program, and only 29.4% of participants reported smoking every day. In addition, almost half of participants (44.9%) reported living with another smoker at home.

Participants also reported using a number of different evidence-based smoking cessation pharmacotherapies over the course of the program. Almost one-fifth (19.7%) reported any NRT use during the program, with the nicotine patch (15.2%) and the nicotine gum (10.8%) being the two most commonly used therapies by a wide margin. A smaller proportion of participants (7.2%) reported using one of the two available prescription cessation medications, Zyban® or Chantix®, culminating in a total of 19.8% reporting any evidence-based pharmacotherapy use while enrolled in the program. This means that almost all participants that reported using a prescription cessation medication also used one or more NRTs during the program. The vast majority of participants completed the program in English, (93.0%) with the remaining participants receiving the program in Spanish (6.0%) or Polish (1.0%). The original full (six hour-long sessions in seven weeks) program was delivered to 15.1% of participants, with 44.5% participating in the revised full program and the remaining 40.4% receiving the short program (three hour-long sessions in four weeks).

Table 3 displays the mean knowledge scores for each of the four included Likert scale items in pretest and posttest (see Appendix), with a score of seven representing a strong agreement with the scientific consensus on each prompt. At pretest, participants were in weakest agreement with experts on whether alternative techniques such as lasers and hypnosis are evidence-based smoking cessation methods, with a mean score of 4.05. At pretest, participants were in strongest agreement on whether smoking cessation pharmacotherapies are proven by scientific evidence to increase one's chances of quitting, with a mean knowledge score of 5.40. After the ten-minute education session led by program facilitators, participants significantly improved with regards to all four

knowledge items and the mean for all the items, with all T-scores exceeding 12.12 for the two-sided matched pairs T-tests. These corresponding p-values were all less than 0.0001.

At the education session posttest, participants agreed most strongly with the scientific consensus by disagreeing that NRTs can cause cancer, with a mean score of 6.08. Just as in the pretest, participants were in weakest agreement with researchers on whether alternate methods could help one quit smoking at the post, with an average score of 4.97 out of seven. This improvement of 0.93 over the pretest score of 4.05 points was the greatest difference observed between the pretest and posttest assessments of any individual item. The calculated means of all four included items were 4.97 for the pretest, 5.78 for the posttest, and 0.82 for the difference.

Neither the correlation coefficients between all study variables nor the consideration of VDPs and conditional indices highlighted any collinearity concerns in the computed logistic regression models. Only one pair of variables, Hispanic ethnicity and choosing "other" as one's race, were strongly correlated with one another ($|\rho| > 0.7$). None of the three tobacco knowledge measures had a $|\rho|$ greater than 0.17 when compared to self-reported use of evidence-based cessation pharmacotherapy while enrolled in the program, indicating weak associations. In addition, no model had any conditional indices greater than 30, so no covariates were excluded from any of the logistic regression models before the backwards elimination procedure.

Table 4 shows the final results of all six logistic regression models that calculate the odds ratios of successful smoking cessation for each knowledge measure, with and without pharmacotherapy use as potential mediators. These models control for all covariates that remained after likelihood ratio tests eliminated variables that did not

significantly improve the models' goodness of fit. In these models, an odds ratio greater than the null means that variable increased CTQ participants' odds of successfully quitting smoking during the CTQ program, while an odds ratio below the null means that the variable is associated with a decreased odds in quitting smoking by the end of the program compared to a referent. None of the variables dropped from the presented models in the backwards elimination procedure were determined to be confounders of the relationship between knowledge score and smoking cessation based on the 10% rule, so they were not included in the final models. Dropping statistically significant variables did not lead to greater precision in the estimation of exposure variables of interest nor a violation of the 10% rule, so these sufficiently parsimonious models are presented as the final outcome of the modeling procedure.

While all three tobacco knowledge measures had odds ratios greater than the null after controlling for covariates that significantly impacted the model's goodness of fit, none of these odds ratios were statistically significant (α=0.05). The odds ratio for the knowledge pretest score was 1.11 (95% CI [0.93, 1.32]) controlling for cessation pharmacotherapy use, and 1.09 (95% CI [0.92, 1.30]) without controlling for pharmacotherapy use. The odds ratio for the knowledge score at posttest was 1.13 (95% CI [0.99, 1.30]) while controlling for pharmacotherapy use, and 1.13 (95% CI [0.99, 1.29]) without controlling for pharmacotherapy use. The odds ratio for the knowledge score difference between pretest and posttest was 1.02 (95% CI [0.87, 1.20]) controlling for medication use, and 1.03 (95% CI [0.88, 1.20]) without controlling for pharmacotherapy use.

Pharmacotherapy use was found to significantly increase the odds of smoking cessation in two of the three models that included that variable as a predictor. In the knowledge pretest model, pharmacotherapy use had an odds ratio of 1.71 and a 95% CI of (1.00, 2.92). In the knowledge posttest score model, cessation medication use had an odds ratio of 1.67 (95% CI [1.00, 2.79]). For the model that includes the difference between knowledge scores, cessation medication use was not found to be statistically significant, with an odds ratio of 1.43 and a 95% CI of (0.81, 2.53).

Despite not having a statistically significant effect estimate in any of the models, age was determined to significantly impact goodness of fit in all models, and is thus included in all of the models. The only other variable to be included in all models is the program iteration. Compared to the referent group of the revised long program, the original long program statistically significantly increases one's odds of quitting smoking by the end of the program in four of the six models, while the short program is statistically associated with a decreased odds of successful cessation in all models.

Each knowledge measure had a different set of covariates included in the final models based on significant improvement of the models' goodness of fit. There are two findings from these additional covariates that bear mentioning. First, where educational attainment was included in these models, there appears to be a dose-response relationship, with lesser educational attainment corresponding to lower odds of smoking cessation. In the model including knowledge pretest score but not the use of cessation medication, the odds of cessation among those who attended some graduate school was 0.69 (95% CI [0.31, 1.57]) compared to the referent of graduate school completion, while those who did not graduate high school had an odds of smoking cessation of 0.32 (95%

CI [0.16, 0.63). Second, in models where racial identity was included, it appears that African Americans are at a disadvantage compared to all other racial groups with regards to smoking cessation. Compared to the African American referent group, all other racial groups had an odds of smoking cessation greater than the null, with some of these ORs being statistically significant. The racial group that was most successful in quitting smoking was Native Americans (OR = 6.89, 95% CI = [1.18, 40.28] in the knowledge score difference model that does not control for cessation medication use), though there were only eight such individuals in the study sample.

Discussion

Key Findings

This analysis did not find any evidence that tobacco-specific health knowledge, as measured in four Likert items from the CTQ program, was associated with one's success in quitting smoking by the end of the CTQ program. These findings are not directly comparable to other results in the literature, as no peer-reviewed studies were identified that looked at tobacco-specific health knowledge prospectively alongside a smoking cessation intervention. However, to the degree that health knowledge can be understood to be a component of health literacy (6,12), these results are somewhat contradictory to work that has found that health literacy impacts one's ability to quit smoking and stay smoke-free in a cohort of low socioeconomic smokers (33). That being understood, the odds ratio estimates corresponding to all three knowledge scores, with and without including pharmacotherapy use as a covariate, are all above the null, just not significantly so.

The results of this study also partially confirm the scientific consensus that using evidence-based pharmacotherapies helps one quit smoking (3-5). However, this study found only a weak correlation between pharmacotherapy use and any of the tobacco knowledge measures, so there is no evidence to conclude that pharmacotherapy use is a mediator of the relationship between tobacco knowledge and smoking cessation. This is surprising because these knowledge scores are based in part on correctly understanding which cessation medications have and have not been demonstrated to help one quit smoking, with two of the four questions used to compute these scores relating to this topic. In addition, because the inclusion or exclusion of this variable in the models does

not impact the effect estimate for any of the knowledge scores by at least 10%, the use of smoking cessation medication(s) is also not a confounder of the relationship between the exposure and outcome of interest.

With regards to the success of the program, the 29.3% of CTQ participants in this study sample that quit smoking is comparable to the observed cessation rates in an earlier study of the CTQ program, which found that among participants who completed the program (program completion was an inclusion criteria for this study, but the earlier study analyzed participant data on an intent-to-treat basis), 36% of full program enrollees (including both the original and revised long program participants) and 22% of short program enrollees successfully quit smoking by the end of the program (38). This earlier study also found that educational attainment and cessation medication use were predictors of successful cessation, largely confirming the results of this study (38). The two studies disagreed as to whether having a smoker in the household was significantly associated with smoking cessation (38), as the earlier study did and this analysis found no such association in any of the models. It must be reiterated that these earlier findings are for an intent-to-treat study analysis, which involves analyzing a fundamentally different study sample than for this study.

The fact that the original long program significantly outperformed the revised long program with regards to successful smoking cessation in a majority of the models is also an unexpected finding, since no alterations at all were made to the long program CTQ curriculum itself. This rules out the possibility that some change to the CTQ program had the unintended consequence of making the long program less efficacious with regards to smoking cessation. A possible explanation for this observation is that

earlier recruitment efforts made by peer cessation leaders before the institution of the revised long program were less successful at enrolling participants of lower socioeconomic status into the CTQ program. Perhaps these individuals were less likely to successfully quit smoking as they participated in the revised long program with greater frequency.

Strengths and Limitations

There are at least three strengths of this study. First, the primary strength of this research is that it fills a gap in the literature by studying health knowledge and successful smoking cessation in the context of a cessation intervention. Second, this relatively large and diverse study sample with regards to covariates like race, ethnicity, and educational attainment, allows for greater precision of effect estimates calculated by logistic regression models. Third, there were several covariates available in the dataset that provided an opportunity to better understand the relationship between tobacco knowledge and tobacco cessation among CTQ program participants.

Despite these strengths, there were at least six limitations to this study. First and perhaps most importantly is the relatively low degree of generalizability of these conclusions based on the study sample. CTQ participants constitute a non-probabilistic sample of Chicago-area adult cigarette smokers, so conclusions made from these data should not be extrapolated to any external populations, including all Chicago-area adult smokers. Second, all study data are self-reported from the four different surveys administered to participants over the course of the CTQ program. In any study, this makes recall bias a potential threat to the validity of calculated effect estimates, but social desirability bias could have an especially strong effect on self-reported tobacco use both

at baseline and at posttest. Laboratory cotinine testing can be used to confirm self-reported tobacco abstinence (39), but because CTQ is more a community health intervention than it is a research dataset, no such testing was performed on study participants. A third limitation is that seven-day abstinence of cigarette smoking might not be long enough a period, laboratory confirmed or not, to adequately judge sustainable smoking cessation. Though seven-day abstinence is understood to be a valid measure of smoking cessation, 30-day prolonged abstinence might be a more accurate measure, since there is value in knowing the degree to with CTQ can assist participants in quitting smoking long-term (40). With no participant follow-up conducted in the weeks or months after the conclusion of the CTQ program, this study is not able to assess 30-day abstinence from cigarettes. Fourth, the fact that posttest tobacco knowledge was assessed immediately after the education session in the first CTQ meeting means that perhaps this measure is not as accurate as it would be if tobacco knowledge were measured towards the end of the CTQ program, when smoking cessation was measured (35).

A fifth potential limitation with the CTQ dataset from a research perspective lies in the decentralized manner by which the program is delivered to participants. After the one-day certification course, trained leaders were free to administer the program in whatever manner they saw fit with little or no oversight from the University of Chicago or RHA. Invariably, some peer leaders will be better than others at delivering the program, which could lead to lower rates of smoking cessation among some participants in a non-random manner. Some leaders might also be negligent in sending completed surveys back to RHA for data entry upon the completion of their programs, as they were instructed to do, which might also introduce bias into the dataset. However, this

decentralized organization is responsible for the large sample size of this study achieved with limited funding and effort invested into participant recruiting by RHA. By training dozens of community stakeholders to recruit participants interested in quitting smoking on their own time and to deliver the CTQ program with minimal oversight, CTQ can be administered to far more people than RHA alone would have the capacity to reach with their own employees.

Finally, participant attrition is another important source of bias in this study. Participants might be more likely to drop out of the program prematurely, or at least not attend the final program session when follow-up data are recorded, if they judge themselves to be unsuccessful or unlikely to be successful at achieving abstinence from tobacco products by the conclusion of the program, thus artificially elevating the efficacy of the program. Out of 1,789 total CTQ participants as of March 2015, only 60.8% completed the program in full based on session attendance. Unfortunately, this will likely be a drawback to any study on tobacco cessation interventions and other addiction interventions, as some participants will inevitably become discouraged with lack of progress and fail to follow through for the duration of the program. If health knowledge plays a role in this association between dropping out of the program and lack of successful smoking cessation, program fidelity becomes an unmeasured confounder in this study.

Future Directions

There are at least three different ways in which future research can build off of the results of this study. First, future research should utilize a better-validated measure of tobacco knowledge in order to obtain more accurate effect estimates of its impact on successful smoking cessation. This is important because developing and using a better measure of tobacco knowledge would more accurately assess the relationship between tobacco-specific health knowledge and smoking cessation. The three knowledge measures included in the six regression models were based on only the four relevant Likert scale items answered by the entire CTQ study sample. Beyond a simple assessment of face validity, no other work was done to understand which of these measures best operationalizes the concept of health knowledge. It is possible that health knowledge was not statistically linked to better odds of successful smoking cessation because the knowledge measures employed by this study did not accurately measure tobacco-specific health knowledge. It should be noted that while health knowledge is related to health literacy, there is no reason to assume that these tobacco knowledge scores are accurate measures of health literacy.

Second, future research could employ an experimental design in which an education session meant to increase tobacco knowledge, much like the one that is a part of the first session of all CTQ programs, is compared against a cessation program without efforts made to increase tobacco-specific health knowledge. This study design is advantageous because one could make causal claims about the relationship between health knowledge and smoking cessation, should an association be found in such a study. Finally, future research in this realm could also employ a more accurate and sustainable

definition of abstinence from cigarette smoking. Testing self-reported cessation results with nicotine metabolite testing and/or asking about 30-day abstinence from cigarettes instead of seven-day abstinence would eliminate social desirability and recall biases in the outcome variable, while also ensuring that the employed cessation measure is better correlated with long-term abstinence from cigarettes (40). Quitting smoking and staying smoke-free for several years, not merely quitting for weeks or months before smoking again, is causally related to the most significant positive health outcomes (e.g., lowering one's risk of stroke and lung cancer) (3). Thus all smoking cessation interventions should ideally be evaluated on their ability to lead to sustainable, long-term abstinence from cigarette smoking instead of abstinence that might possibly be more short-term.

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Tables

Table 1: Descriptive statistics for selected demographic variables as measured by the Courage to Quit (CTQ) smoking cessation program (n=1,062)

Variable	Mean (SD) or % (N)	Missing (N)
Demographic Variables		
Age (years)	46.7 (12.5)	59
Employment status (past six months)		77
Full-time	40.3% (397)	
Part-time or occasional work	13.9% (137)	
Retired	6.8% (67)	
Disabled	14.2% (140)	
Unemployed	23.1% (227)	
Student	1.7% (17)	
Educational attainment		62
Some high school or less	19.0% (190)	
High school graduate/GED	26.3% (263)	
Some college	28.6% (286)	
College graduate	14.7% (147)	
Some graduate school	4.7% (47)	
Graduate degree	6.7% (67)	
Race		109
African American/Black	48.4% (461)	
Caucasian/White	34.5% (329)	
Asian/Pacific Islander	3.6% (34)	
Native American	0.8% (8)	
Biracial	0.8% (8)	
Other	11.9% (113)	
Ethnicity (Hispanic)	17.9% (165)	138
Marital status		42
Married or living as married	30.8% (314)	
Divorced or separated	20.4% (208)	
Widowed	5.6% (57)	
Single	43.2% (441)	

Table 2: Descriptive statistics for selected cigarette smoking, pharmacotherapy use, and program characteristic variables as measured by the Courage to Quit (CTQ) smoking cessation program (n=1,062)

Variable	Mean (SD) or % (N)	Missing N
Smoking and Pharmacotherapy		
Days smoked in past week, baseline		61
7 days (daily)	82.1% (822)	
5-6 days	9.0% (90)	
3-4 days	5.0% (50)	
1-2 days	3.9% (39)	
Days smoked in past week, end of program		17
7 days (daily)	29.4% (307)	
5-6 days	7.6% (79)	
3-4 days	12.9% (135)	
1-2 days	20.9% (218)	
0 days (week-long smoking cessation)	29.3% (306)	
Nicotine therapy(ies) used, end of program		88
Patch	15.2% (148)	
Gum	10.8% (105)	
Lozenge	0.7% (7)	
Inhaler	0.3% (3)	
None	80.3% (783)	
Other smokers in household (Y)	44.9% (457)	45
Use of prescription cessation medication, end of program (Y)	7.2% (70)	89*
Any pharmacotherapy use, end of program (Y)	19.8% (193)	88
Program Characteristic Variables		
CTQ program language		13
English	93.0% (976)	
Spanish	6.0% (63)	
Polish	1.0% (10)	
Program Version		6
Full version (original)	15.1% (159)	
Short version	40.4% (427)	
Full version (revised) **	44.5% (470)	

* 89 participants did not provide information on evidence-based pharmacotherapy use in the final survey of their CTQ program

** The full six-week program was updated by removing three of the tobacco knowledge Likert items, correcting minor errors, and making format changes to the program booklet in order to make the program easier to administer for both peer leaders and CTQ participants. The program curriculum itself was not altered.

Table 3: Mean knowledge scores and t-test results based on selected pretest and posttest knowledge Likert scale items measured before and after a brief tobacco education session as part of the Courage to Quit (CTQ) smoking cessation program (n=1,062)

Tobacco/Program Knowledge Question	**Mean Score (SD)**			**T-score**
	Pretest	Posttest	Difference	**(df)**
1) There are several stop smoking medications such as nicotine replacement (patch, gum, etc), Zyban®, or Chantix® that have been shown by scientific evidence to improve one's chances of quitting smoking.	5.40 (1.67)	6.04 (1.43)	0.67 (1.71)	12.12* (968)
2) Behavioral counseling, in a group or individual setting, has been shown by scientific evidence to improve one's chances of quitting smoking.	5.23 (1.61)	6.04 (2.57)	0.75 (1.67)	13.96* (968)
3) There are several alternative techniques such as lasers, hypnosis, acupuncture, and herbs that have been shown by scientific evidence to improve one's chances of quitting smoking.	4.05 (1.86)	4.97 (2.06)	0.93 (2.05)	14.03* (965)
4) Nicotine replacement products (patch, gum, lozenge, etc.) can cause cancer.	5.17 (1.76)	6.08 (1.61)	0.92 (1.88)	15.11* (960)
Mean Knowledge Scores	4.97 (0.92)	5.78 (1.17)	0.82 (1.07)	23.41* (949)

* $p < 0.0001$

Table 4: Results of multivariate logistic regression models calculating the odds ratios of successful smoking cessation as measured in the Courage to Quit (CTQ) smoking cessation program (n=1,062)

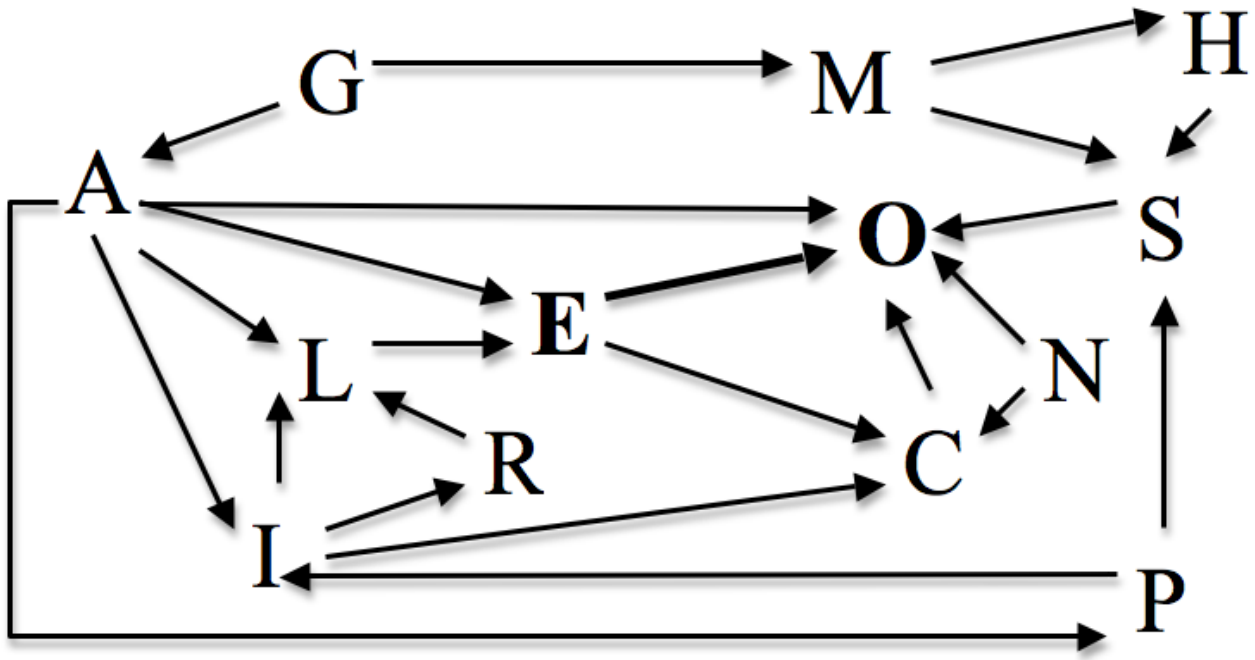
Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Exposures	Odds Ratios (95% Confidence Intervals)					
Knowledge Pretest Score †	1.11 (0.93, 1.32)	1.09 (0.92, 1.30)	---	---	---	---
Knowledge Posttest Score †	---	---	1.13 (0.99, 1.30)	1.13 (0.99, 1.29)	---	---
Knowledge Score Difference †	---	---	---	---	1.02 (0.87, 1.20)	1.03 (0.88, 1.20)
Cessation Medication †	1.71* (1.00, 2.92)	---	1.67* (1.00, 2.79)	---	1.43 (0.81, 2.53)	---
Covariates						
Age (years)	1.00 (0.98, 1.01)	1.00 (0.98, 1.01)	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)	1.00 (0.98, 1.01)
Educational attainment ‡						
Some graduate school	0.50 (0.21, 1.23)	0.69 (0.31, 1.57)	---	---	---	---
College graduate	0.53 (0.26, 1.08)	0.59 (0.31, 1.13)	---	---	---	---
Some college	0.48* (0.25, 0.93)	0.54* (0.30, 0.99)	---	---	---	---
High school graduate/GED	0.45* (0.23, 0.87)	0.50* (0.27, 0.91)	---	---	---	---
Some high school or less	0.29** (0.14, 0.60)	0.32** (0.16, 0.63)	---	---	---	---
Race §						
Caucasian/White	---	---	---	---	1.53* (1.06, 2.21)	1.46* (1.04, 2.06)
Asian/Pacific Islander	---	---	---	---	2.16 (0.98, 4.78)	2.23* (1.02, 4.88)
Native American	---	---	---	---	6.54* (1.11, 38.63)	6.89* (1.18, 40.28)
Biracial	---	---	---	---	1.77 (0.30, 10.39)	2.18 (0.45, 10.60)
Other	---	---	---	---	1.16 (0.64, 2.10)	1.15 (0.66, 2.00)
Other smokers in the household (Y)	1.34 (0.96, 1.86)	1.26 (0.92, 1.71)	---	---	---	---
Number of days smoking in past week, baseline ¶						
5-6 days	1.18 (0.68, 2.02)	1.25 (0.75, 2.09)	1.36 (0.81, 2.27)	1.44 (0.88, 2.37)	---	---
3-4 days	1.34 (0.61, 2.95)	1.19 (0.56, 2.54)	1.29 (0.63, 2.63)	1.33 (0.67, 2.64)	---	---
1-2 days	1.82 (0.86, 3.86)	1.98 (0.95, 4.14)	1.82 (0.89, 3.72)	1.99 (0.99, 3.99)	---	---
Type of program ‖						
Long program (original)	1.81* (1.01, 3.24)	1.46 (0.97, 2.20)	2.08* (1.16, 3.74)	1.68 (1.12, 2.54)	2.12* (1.14, 3.97)	1.69* (1.11, 2.57)
Short program	0.33*** (0.21, 0.53)	0.44*** (0.31, 0.62)	0.32*** (0.20, 0.50)	0.41*** (0.29, 0.58)	0.36*** (0.22, 0.57)	0.41*** (0.28, 0.61)

* $p < 0.05$
** $p < 0.01$
*** $p < 0.0001$

† Effect estimates are adjusted for covariates included in the model as indicated by likelihood ratio tests. Included covariates also have effect estimates presented above
‡ Obtaining a graduate school degree serves as referent
§ African American/Black race serves as referent
¶ Smoking for seven days in the week prior to program initiation serves as referent
‖ The revised long form CTQ program serves as referent

Figures

Figure 1: Directed acyclic graph (DAG) of hypothesized causal relationships between variables related to tobacco-specific health knowledge and smoking cessation



E [EXPOSURE] = Tobacco-specific health knowledge
A = Educational attainment
G = Age
I = Income
M = Marital status
P = Employment status
S = Social support

O [OUTCOME] = Successful smoking cessation
C = Use of smoking cessation medications
H = Smoker in the household
L = Health literacy
N = Number of cigarettes smoked per day at baseline
R = Race/ethnicity

Appendix

Appendix: Excerpt of Courage to Quit participant notebook showing tobacco knowledge pretest items and Likert response options (identical items also presented in posttest)

Client Number _____
(Site)-(Program Leader Initials)-(#)

Date _____

Courage to Quit Pre-Orientation Survey

The following questions ask you about quitting smoking and other related behaviors. All information you provide will be kept in strict confidence and will only be identified by your unique client number. Please place the number on the scale below from 1 (Strongly Disagree) to 7 (Strongly Agree) on the line next to each statement.

Strongly Disagree	Moderately Disagree	Mildly Disagree	Neutral	Mildly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

_____ 1. There are several stop smoking medications such as nicotine replacement (patch, gum, etc), Zyban®, or Chantix® that have been shown by scientific evidence to improve one's chances of quitting smoking.

_____ 2. Behavioral counseling, in a group or individual setting, has been shown by scientific evidence to improve one's chances of quitting smoking.

_____ 3. There are several alternative techniques such as lasers, hypnosis, acupuncture, and herbs that have been shown by scientific evidence to improve one's chances of quitting smoking.

_____ 4. Nicotine replacement products (patch, gum, lozenge, etc.) can cause cancer.

_____ 5. If I have a slip or setback, I will be judged by the program leader and participants and I will not be welcome to continue in the program.