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Social Network Attributes Associated With Conversations About Smoking and Cessation and Differences by Socioeconomic Status

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SOCIAL NETWORK ATTRIBUTES ASSOCIATED WITH CONVERSATIONS ABOUT SMOKING AND CESSATION AND DIFFERENCES BY SOCIOECONOMIC STATUS

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Abstract

Conversations about smoking and cessation in response to cessation messages appear to encourage quit attempts, yet there is some evidence that smokers with lower income and education have these conversations less often than their counterparts with higher income and education. No research has investigated the social network characteristics that encourage smokers to have these conversations or the mechanisms for SES differences in these conversations. Because social factors play a role in SES disparities in smoking and cessation as well as other health behaviors and outcomes, social network characteristics likely explain some SES differences in conversations about smoking and cessation. The purpose of this dissertation is to investigate the relationships between network characteristics and conversations about smoking and cessation (Aim 1) as well as the role of networks in SES differences in these conversations (Aim 2).

Data for this research came from a convenience sample of adult smokers in South Carolina, North Carolina, and New York state. At baseline, participants reported their network characteristics and received a 14-day supply of cigarettes with packs modified to include cessation messages on the inside and/or outside of their packs. Each night for 14 days, participants completed a survey that queried their conversations about smoking and cessation with network members in the prior 24 hours. For Aim 1, I used bivariate and adjusted mixed effects logistic regression models to assess the relationships between social network characteristics and these conversations, with separate models predicting

the likelihood of conversations about the dangers of smoking and about the benefits of quitting on any given day. For Aim 2, I used generalized structural equation models and bootstrapped confidence intervals (for indirect effects) to assess the associations of income and education with conversations about smoking and cessation as well as the mediating role of social networks characteristics.

In models adjusting for all network and control variables, network disapproval of smoking and network smoking prevalence were positively associated with the likelihood of conversations about smoking harms and quitting benefits. Network size was negatively associated with, and average closeness to alters was positively associated with, conversations about quitting benefits. Furthermore, contrary to prior research, low SES smokers reported more conversations about smoking and cessation within their strong networks. However, network disapproval of smoking was associated with more conversations for high SES smokers.

The findings from this dissertation research imply that approaches to increase social norms against tobacco use – which often involve societal-level interventions like policies– may influence more interpersonal interactions that encourage conversations. Furthermore, study results suggest that smokers converse with other smokers about both the harms of smoking and the benefits of cessation. Though previous research suggests that being around other smokers makes cessation more difficult, our findings suggest that having other smokers in one's network may encourage discussions that encourage quitting. More research, likely with much larger sample sizes, is needed to understand if the number of smokers in one's networks moderates the influence of these conversations on cessation. Finally, the results of this research also suggest that close network members

of smokers from lower SES groups are resources for smoking cessation. Interventions aimed at low SES smokers may consider involving these network members by encouraging more conversations and ensuring these network members have the tools and information needed to be as helpful as possible in their efforts to support smokers' cessation attempts.

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Chapter 1

Introduction

Despite decades of antismoking interventions and substantial declines in smoking prevalence, smoking is still the leading cause of preventable death in the US (Jamal et al., 2018). Moreover, substantial socioeconomic disparities persist and have even increased in smoking prevalence (Agaku, Odani, Okuyemi, & Armour, 2020; Cornelius, Wang, Jamal, Loretan, & Neff, 2020; Drope et al., 2018; Fagan, Shavers, Lawrence, Gibson, & O'Connell, 2007; Garrett, Martell, Caraballo, & King, 2019), cessation rates (Fagan et al., 2007; Hiscock, Judge, & Bauld, 2011; Kotz & West, 2009; Reid, Hammond, Boudreau, Fong, & Siahpush, 2010; Ruokolainen et al., 2021; Sheffer et al., 2012), morbidity (Clegg et al., 2009; Henley et al., 2016), and mortality (Denney, Rogers, Hummer, & Pampel, 2010; Glei, Lee, & Weinstein, 2020; Gregoraci et al., 2017; Henley et al., 2016; Ho & Fenelon, 2015; Sasson, 2016). To reduce the burden of smoking on public health, it is critical to eliminate disparities in smoking by socioeconomic status (SES). However, there is a lack of cessation intervention research among smokers with low SES (Courtney et al., 2015), and novel approaches are needed to address these disparities (Drope et al., 2018).

Cigarette package messages such as pictorial health warning labels (PHWLs) placed on the outside of packs are an essential component of comprehensive tobacco control. PHWLs are used by most countries and recommended by the World Health

Organization as one of the most effective strategies for communicating smoking risks and reducing smoking prevalence (Canadian Cancer Society, 2018). While there are typically SES disparities in the effects of communication interventions (Niederdeppe, Kuang, Crock, & Skelton, 2008; Viswanath, 2006), cigarette package messages expose all smokers to antismoking information each time they smoke, eliminating differences in message exposure.

Several studies have found that affective responses (Bekalu et al., 2018; Gibson et al., 2015) and cognitive reactions (Bekalu et al., 2018; Cantrell et al., 2013; Gibson et al., 2015; Hammond et al., 2012; Swayampakala, Thrasher, Yong, et al., 2018; Thrasher et al., 2010) to PHWLs are either equal by SES or higher among low SES smokers. However, few studies have compared interpersonal conversations that occur in response to PHWLS by smokers' SES. These conversations are an important outcome because they are associated with subsequent quit attempts (Brewer et al., 2016; Hall et al., 2015; Lambert, Davis, Popova, & Thrasher, 2020; Morgan et al., 2017; Thrasher et al., 2016). Of the two studies that have reported SES differences in conversations about cigarette package warnings, both found that smokers with lower income and education discuss warnings less frequently than higher SES smokers (Lambert et al., 2020; Thrasher et al., 2016). No studies have assessed the mechanisms for differences in conversations about cessation messages by SES, but social conditions (e.g., smoking norms and social support for cessation) help account for SES disparities in smoking and cessation (Link & Phelan, 2009) and disparities in the effects of cessation messages (Niederdeppe et al., 2008). Therefore, smokers' social network characteristics are a key candidate for explaining SES differences in conversations sparked by cigarette warnings. No studies have investigated

associations between smokers' social network characteristics and conversations about smoking and cessation, much less whether social network characteristics mediate SES effects on these conversations.

This dissertation used social network analysis and ecological momentary assessments (EMA) to investigate conversations about smoking and cessation in the context of exposure to novel cigarette labeling messages. This research fills at least two critical gaps in the literature on conversations about smoking and cessation by 1) assessing the social network attributes that predict conversations about smoking and cessation and 2) investigating potential social network mechanisms for differences in the frequency of these conversations by SES. This research is innovative in that it is the first to use EMA to investigate conversations about smoking and cessation and the first to combine self-reported egocentric social network methods with EMA data to assess interpersonal communication. The results of this research could be used to enhance the effectiveness of cessation messages overall as well as to improve the equity of their effects by SES.

The overall goal of this dissertation is to investigate the relationships between network characteristics and conversations about smoking and cessation, including the role of networks in SES differences in these conversations. **Specific Aim 1 is to assess associations between the characteristics of egocentric networks and the likelihood of having conversations with network alters.** The overall hypothesis for Aim 1 is that network attributes will influence the likelihood of conversations about smoking harms and cessation benefits with network alters. The specific hypotheses and research questions for Aim 1 can be found in Table 2.1.

Specific Aim 2 is to assess the associations of socioeconomic status with egocentric network attributes and the frequency of conversations with network alters. The overall hypothesis for Aim 2 is that socioeconomic status will influence network attributes, which will, in turn, influence the frequency of conversations about smoking harms and cessation benefits with alters. The specific hypotheses and research questions for Aim 2 can be found in Table 2.2.

To achieve these two specific aims, I used data from a between-subjects randomized controlled trial among U.S. adult smokers (N=367) in which participants were exposed to novel cessation messages on their cigarette packs for 14 days. Participants' SES (income and education) and egocentric social networks were assessed at study baseline. Then, over the 14-day study period, participants responded to daily surveys. These daily surveys asked participants to report conversations about smoking harms and quitting benefits with the network alters they named at baseline. This dissertation fills critical gaps in the understanding of conversations about smoking and cessation, including the social network attributes that encourage conversations and the potential social network mechanisms for differences in the frequency of these conversations by SES.

Chapter 2

Background and Significance

Background part 1: Aim 1 (To assess associations between the characteristics of egocentric networks and the likelihood of having conversations with network alters)

Social networks, health outcomes, and health interventions

Social relationships appear to casually influence health (Howick, Kelly, & Kelly, 2019), with relational factors posing a mortality risk of similar magnitude to other behavioral predictors of mortality, such cigarette smoking, diet, and physical activity (Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015; Holt-Lunstad, Smith, & Layton, 2010). Conceptual frameworks linking social networks and health posit that the structure and characteristics of networks influence health behaviors and outcomes through various psychosocial mechanisms, including social support, social stress, social and personal control, symbolic meaning, social influence and comparison, behavioral guidance, self-esteem, belonging and companionship, social engagement, physical contact, access to resources, and social interactions (Berkman & Krishna, 2015; Thoits, 2011; Umberson, Crosnoe, & Reczek, 2010).

Health behaviors also appear to spread through social networks (Christakis & Fowler, 2008, 2012), making networks especially important in understanding how to enhance behavioral interventions. Networks can both mediate and moderate the effects of

health interventions, including media campaigns (Valente & Pitts, 2017). Therefore, if we understand what aspects of networks facilitate behavior change, networks are a potential lever for enhancing, expanding, and sustaining the positive effects of health interventions. It is essential that intervention research incorporate social network analysis to explain how networks influence the effects of public health interventions and can be used to augment and sustain these effects (Valente, 2011; Valente & Pitts, 2017).

Interpersonal communication as a network mechanism of messaging interventions

Interpersonal communication about health messages is a network-level mechanism of messaging effects (Valente, 2011). Conversations about messages indicate that people exposed to the messages are socially processing message content, which may both enhance and sustain the effectiveness of messages (Valente, 2011; Valente & Pitts, 2017). Indeed, conversations sparked by smoking cessation messages lead to further engagement with message content (Morgan et al., 2018) and are associated with subsequent quit attempts (Lambert et al., 2020; Morgan et al., 2018; Thrasher et al., 2016; van den Putte, Yzer, Southwell, de Bruijn, & Willemsen, 2011). In order to fully characterize conversations about cessation messages, it is critical to evaluate the social network characteristics that encourage this network-level outcome (Valente, 2011).

Some research has investigated the characteristics of discussants in conversations sparked by PHWLs (Hall et al., 2015; Morgan et al., 2017; Ramanadhan, Nagler, McCloud, Kohler, & Viswanath, 2017). While conversations sparked by messages were most often with other smokers, the majority of participants in these studies also reported having some conversations with non-smokers (Hall et al., 2015; Morgan et al., 2017). Of

the three studies that have reported the characteristics of discussants in conversations about PHWLs, only one used social network methods to assess these characteristics (Ramanadhan et al., 2017). In that study, smokers viewed several PHWLs a single time in an experimental setting and, two weeks later, reported conversations about these messages among their personal health discussion networks (i.e., people with whom they discussed health issues in the past six months) (Ramanadhan et al., 2017). The characteristics of smokers' networks and, separately, of discussants in conversations about PHWLs were reported; however, that study did not assess if network characteristics were associated with conversations about the PHWLs.

Though Ramanadhan et al. (2017) and other studies characterize the people with whom smokers talk about cessation messages, no research has assessed the relationship between smokers' network characteristics and these conversations. Therefore, the social network characteristics that encourage these conversations are unknown. To better understand how interventions can increase the occurrence of conversation about smoking and cessation, it is critical to identify the social network conditions that encourage them (Valente, 2011). Despite the underutilization of social network analysis in research on cessation conversations, network methods are both well-suited for and critical to advancing this area of research.

In summary, the network characteristics that encourage conversations about smoking and cessation are unknown. In this dissertation, I address the lack of attention to the social network influences on these conversations by investigating the associations of social network attributes with conversations about smoking and cessation in the context of exposure to novel cessation messages. The results of this dissertation may inform how

networks can be leveraged to enhance and sustain the effects of cessation messages through interpersonal conversations (Valente, 2011; Valente & Pitts, 2017).

Other limitations in warning label studies

In addition to not assessing social networks, prior studies examining the characteristics of discussants in conversations sparked by PHWLs have several other limitations. First, all of these studies used imprecise measures or assessments of discussant characteristics. Two studies reported the percent of participants who spoke with one or more types of relational tie (e.g., family member) (Hall et al., 2015; Morgan et al., 2017). Another study reported the characteristics of discussants in more detail, including the percent of discussants who fit a certain characteristic (e.g., friend); however, each discussant was only counted once regardless of the number of conversations with that person (Ramanadhan et al., 2017). Therefore, it is unclear whether the characteristics of discussants most prevalent in these previous studies will be the same characteristics of smokers' networks that encourage more conversations about smoking and cessation. Second, prior studies on conversations sparked by PHWLs have all relied on retrospective assessments that asked participants to report conversations they had in the past week or past two weeks (Hall et al., 2015; Morgan et al., 2017; Ramanadhan et al., 2017). Therefore, these studies are subject to recall bias.

The limitations in prior research on conversations sparked by cessation messages warrant further investigation that directly assesses the associations between network characteristics and conversations. This dissertation addresses these limitations by combining social network analysis with daily assessments (EMA) of conversations about

smoking and cessation. Furthermore, compared to prior studies in this area, the proposed research will reduce the threat of recall bias, as the data are from daily surveys that assessed conversations that occurred in the past 24 hours. Therefore, this dissertation provides the most comprehensive and accurate analysis to date of the social network contexts of conversations about smoking and cessation.

Explanation of measurement of conversations in this dissertation

Much of the prior research on conversations sparked by cessation messages has assessed conversations specifically about cessation messages. However, discussing messages alone does not appear to influence subsequent cessation outcomes; some studies suggest that conversations about antismoking messages only lead to cessation outcomes when quitting smoking is also discussed (Jeong, Tan, Brennan, Gibson, & Hornik, 2015; van den Putte et al., 2011). Conversations sparked by cessation messages also appear more likely to encourage cessation outcomes when conversations characterize the messages favorably (Brennan, Durkin, Wakefield, & Kashima, 2016) or smoking negatively (Ramanadhan et al., 2017) and when discussants pressure smokers to quit smoking (Dunlop, Cotter, & Perez, 2014). Therefore, in this dissertation, analyses will be limited to conversations about two topics that are likely to lead to cessation outcomes according to prior research: 1) the harms of smoking and 2) the benefits of quitting smoking.

Explanation of study design for this dissertation

Data for this dissertation comes from a study in which all participants were randomized to one of four cigarette pack labeling conditions, all of which included

messages with novel content relative to the current labels on packs. Theory and empirical evidence suggest these four message conditions will have varying effects on cessation outcomes. However, this study is not adequately powered to assess most of the effects by message conditions, including conversations about smoking and cessation. Nevertheless, prior research has found that exposure to both less impactful messages (text-only cigarette warnings) and more impactful messages (PHWLs) result in an increase in conversations about quitting and smoking harms in the weeks after smokers are first exposed to them (Brewer et al., 2016). Furthermore, even conversations sparked by weaker messages (text-only cigarette warnings) are associated with subsequent cessation attempts (e.g., Lambert et al, 2020). Thus, I expect that, in the current study, the novel messages across all four conditions should have encouraged conversations. Because this dissertation is focused on the social network characteristics that encourage these conversations, I treat the study design as observational while statistically adjusting for message condition.

Network structural characteristics and conversations

Network size. One structural network characteristic that may affect conversations is network size. Smokers with large networks may have more opportunities to talk about smoking and cessation. Indeed, larger networks are associated with more provision of support for personal concerns (Martí, Bolíbar, & Lozares, 2017) and with seeking health information from family and friends (Askelson, Campo, & Carter, 2011; Song & Chang,

2012).[1] Therefore, I hypothesize that network size will be positively associated with the likelihood of having conversations with alters (H1.1; See Table 2.1).

Tie strength. Tie strength is another structural network attribute that may influence conversations about smoking and cessation. The current study assessed tie strength with measures of frequency of contact and perceived closeness, both of which should influence frequency of conversations with alters. Smokers should have more opportunities to discuss cigarette labeling messages, smoking, and cessation when their networks include alters with whom they frequently communicate. Likewise, close alters may be more likely to bring up personal matters like smoking and cessation, and smokers may be more willing to open up about their smoking to ties they perceive to be close. Indeed, one study found alters who are closer emotionally and in geographic proximity are more likely to provide support for personal matters and health (Martí et al., 2017).

However, people sometimes avoid conversations about important topics with close alters (Small, 2017). Avoiding certain topics with alters could be in part due to embarrassment and fear of judgement or rejection from those people. Indeed, in his book *Someone to Talk To*, Mario Small posits that people avoid difficult conversations with close alters precisely because of the strength of their relationship: "The stronger the tie, the more it can withstand, but the more there is to lose." (Small, Mario Luis. Someone To

[1] The studies demonstrating these associations are not directly comparable with the data used in this dissertation as they used non-truncated network name generators or had a high limit on network size compared to the current study. In contrast, the data for the proposed dissertation comes from a truncated name generator that limited participants' network size to 5 ties (see methods for justification for this decision). No studies to my knowledge have assessed associations between network size and support, health information, or interpersonal discussions using a truncated name generator.

Talk To (p. 89)). Therefore, smokers may avoid conversations about their smoking and cessation with stronger ties.[2]

Therefore, I propose an exploratory hypothesis for the relationship between tie strength and conversations about smoking and cessation: Tie strength (average perceived closeness and baseline frequency of communication) will be associated with the likelihood of having conversations about smoking and cessation with alters (H1.4; See Table 2.1).

Social norms and conversations

Social norms theories. Theories that include the construct of social norms posit that people generally behave in ways that are consistent with the perceived behaviors and expectations of others in society (Chung & Rimal, 2016). While the prevalence of a behavior in a society or social group is a normative influence (i.e., collective norms), most literature on norms focuses on perceived norms, which may not be consistent with a social group's actual behaviors and expectations (Chung & Rimal, 2016).

Two types of perceived norms often used in social norms literature are descriptive norms and injunctive norms, appearing in theories such as the theory of normative conduct (Cialdini, Reno, & Kallgren, 1990) and theory of normative influence (Rimal & Real, 2005). Descriptive norms are perceptions about the prevalence of others who engage in a specific behavior. These norms provide informational cues on what is socially appropriate behavior. Injunctive norms are perceptions about others' approval or

[2] This association may only be true when strong ties disapprove of smoking; Indeed, Small's research suggests that people selectively avoid certain topics with specific close alters, not all close alters.

disapproval of a behavior. These norms encourage people to comply with others' expectations in order to gain or maintain social acceptance and avoid social consequences (Chung & Rimal, 2016; Cialdini et al., 1990).

Roles of descriptive and injunctive norms in influencing behaviors. Descriptive and injunctive norms can be incongruous (e.g., none of my friends smoke, but they do not disapprove of my smoking), which is why is it critical to assess their effects on behaviors separately (Chung & Rimal, 2016). The focus theory of normative conduct provided the first theoretical framework to distinguish descriptive and injunctive norms, positing that their influences on behavior are unique (Cialdini, Kallgren, & Reno, 1991; Cialdini et al., 1990).

The theory of normative social behavior built on Cialdini's early work by specifying the personal and contextual variables that may moderate the influence of descriptive norms (Rimal & Real, 2005). Critically, this theory posits injunctive norms can moderate the influence of descriptive norms on behaviors. That is, even if I believe that most people are not engaging in a behavior, this may not deter me from engaging in that behavior if I also believe that people do not disapprove of the behavior. This is because, if people do not disapprove a behavior, I am unlikely to face social consequences for engaging in that behavior.

Referents for descriptive and injunctive norms. Theorists describe the sources of norms broadly, referring to one's "social group" (Chung & Rimal, 2016; Cialdini et al., 1991; Lapinski & Rimal, 2005). Therefore, these norms can include influence from social referents at multiple levels, including one's society, country, community, peers,

colleagues, friends, network members, and various other social groups. Indeed, there is much variation in the referents used in the social norms literature, and many studies use vague or unspecified referents (Shulman et al., 2017). However, norms at different levels of social influence likely have distinct effects on behavior. Chung and Rimal explain that the proximity or importance of the reference group and the extent to which one identifies with people in the group (i.e., share common values or identity) moderate the influence of norms on behavior (Chung & Rimal, 2016). Therefore, when describing the effects of social norms on behaviors, it is critical to specify not only the type of norm (e.g., descriptive, injunctive) but also the social referents for the norm. The current study assessed norms ats the egocentric network level.

Overview of literature on smoking norms. In studies among adult smokers, norms are generally associated with cessation-related outcomes (Brown, Moodie, & Hastings, 2009; Hammond, Fong, Zanna, Thrasher, & Borland, 2006; Hosking et al., 2009; Rennen et al., 2014; Schoenaker, Brennan, Wakefield, & Durkin, 2018; van den Putte, Yzer, & Brunsting, 2005). Theories of social norms note the importance of distinguishing between the type (Chung & Rimal, 2016; Cialdini et al., 1991, 1990) and source (Chung & Rimal, 2016; Shulman et al., 2017) of norms. Therefore, the following review of the literature on smoking norms will discuss the effects of norms by norm type (i.e., injunctive norms and descriptive norms) and social referents (e.g., society, important others).

Association of injunctive norms with quitting-related outcomes: Differences by referent and proximity. Studies that claim to measure injunctive smoking norms have operationalized this construct inconsistently and not always in ways that align with

the definition of injunctive norms according to theory. For example, van den Putte et al. (2005) measured injunctive norms as acceptability to smoke in various public settings while Schoenaker et al. (2018) measured injunctive norms as embarrassment to tell others you are a smoker (Schoenaker et al., 2018; van den Putte et al., 2005). In the paragraphs that follow, I will summarize studies that measured injunctive norms as perceptions of others' approval (or disapproval) of smoking or cessation as this measurement is consistent with social norms theories (Cialdini et al., 1990; Rimal & Real, 2005) and the measure of injunctive norms in this dissertation.

Among adult smokers, perceiving that others disapprove of smoking is associated with various cessation-related outcomes, including quit attempts (Rennen et al., 2014), smoking abstinence (Hammond et al., 2006), behaviors predictive of quitting (i.e., setting a quit date, limiting smoking) (Schoenaker et al., 2018), intention to quit (Brown et al., 2009; Hammond et al., 2006; Hosking et al., 2009), and prioritization of quitting (Schoenaker et al., 2018). Studies have measured smoking injunctive norms at both the societal level (e.g., the extent to which my society or country approves of smoking) and the interpersonal level (e.g., the extent to which people I know approve of smoking). Some studies measuring injunctive smoking norms combine measures of approval of smoking at various social levels or measures of approval with other similar but conceptually distinct measures. For example, some studies have combined into a single variable perceptions about smoking disapproval of "important people" with perceptions of broader societal smoking disapproval and feeling uncomfortable smoking (Brown et al., 2009; Hammond et al., 2006). Hence, it is unclear which of these measures are associated with cessation outcomes in these studies. However, studies that have examined

the distinct effects of perceived interpersonal and societal smoking approval have found interpersonal disapproval is more strongly and consistently associated with cessation outcomes (Hosking et al., 2009; Rennen et al., 2014; van den Putte et al., 2005).

Though interpersonal norms appear important for influencing smoking, studies of interpersonal norms often measure them with a single item that assesses perceptions of "important people." This measure does not permit separate assessment of perceived norms of different important people, yet norms may vary among one's close network alters. Other studies have assessed interpersonal injunctive norms by asking smokers whether their family and friends approve of smoking (Schoenaker et al., 2018). This measure is also problematic because it combines different groups of people. For an accurate assessment of injunctive norms and their influences on cessation, it is critical to measure perceived approval of individual network alters. Theories of social influence (e.g., dynamic social impact theory: (Latané, 1996; Nowak, Szamrej, & Latané, 1990)) propose that the influence that social network members have on behaviors depends on the multiplicative impact of the number, importance, and proximity of social ties approving or disapproving of a specific behavior. Hence, having just one important tie who disapproves of smoking may be influential on cessation if that tie is more important than the other ties in one's life who are approving or ambivalent about smoking.

A few studies have examined the relationship between perceived quitting approval and cessation outcomes. Orbell et al. (2009) found that an indicator combining perceptions of quitting approval and support from important people partially explained subsequent smoking reduction after a public smoking ban in England (Orbell et al., 2009). It is important to note that this prior study combined items about quitting approval

and support for quitting, which are related but conceptually distinct. Similarly, van den Putte et al. (2005) found perceived approval of quitting from important people was associated with quit intentions. Descriptive norms for quitting and for smoking and perceived societal acceptability of smoking were also associated with quit intentions but less so than perceived approval of quitting from important others (van den Putte et al., 2005).

Injunctive smoking norms as a mechanism of tobacco control interventions. Normative beliefs about smoking are commonly cited as a key mechanism of the effects of social and environmental tobacco control interventions (Cummings, Fong, & Borland, 2009; Fong, Chung-Hall, Craig, & WHO FCTC Impact Assessment Expert Group, 2018; Fong et al., 2006). Several observational studies suggest smoking policies can influence injunctive norms (Durkin, Schoenaker, Brennan, Bayly, & Wakefield, 2021; Hammond et al., 2006; Rennen et al., 2014), and there is some evidence that smoking bans affect downstream cessation outcomes via injunctive smoking norms (Brown et al., 2009; Orbell et al., 2009). Furthermore, a recent study found that exposure to fear-evoking antismoking messages was associated with higher perceived disapproval of smoking from family and friends (Durkin et al., 2021).

Injunctive norms and conversations about cessation. Only one study has assessed the relationship between injunctive smoking norms and conversations about quitting. Schoenaker et al. (2018) found that perceiving that most close family and friends disapproved of smoking was not associated with conversations about quitting (Schoenaker et al., 2018). This finding suggests injunctive smoking norms do not influence cessation conversations. This could be because alters disapproving of smoking

may bring up the topic of quitting, yet subsequent conversations may not occur because the smoker aims to avoid negative interactions with these alters (e.g., pressure, nagging, judgement). However, Schoenaker et al.'s study had limitations that warrant further investigation. Their measures of injunctive norms and conversations about quitting asked about family and friends in the same items. That is, a single item asked whether smokers' family and friends disapproved of smoking; likewise, a single item asked if smokers had recently discussed quitting with family or friends. Furthermore, the assessment of cessation conversations in that study was cross-sectional and asked smokers to recall conversations they had in the past week (Schoenaker et al., 2018).

Other evidence outside the smoking literature suggests injunctive norms may have a negative association with conversations about smoking and cessation. Mario Small's work has demonstrated that people confide in alters who are not close for various reasons (Small, 2013) and often actively avoid discussing important topics with close alters (Small, personal communication). While Small's inquiry in this area is ongoing, avoidance of certain topics with close alters could be in part due to embarrassment and fear of judgement or rejection from these alters. Hence, smokers with close alters disapproving of their smoking may avoid talking about smoking and cessation with these people to avoid judgement, nagging, or otherwise difficult interactions.

Alternatively, network smoking disapproval could encourage conversations about smoking and cessation. Among adult smokers, perceiving that others disapprove of smoking is associated with various cessation-related outcomes, including quit attempts (Rennen et al., 2014), smoking abstinence (Hammond et al., 2006), behaviors predictive of quitting (i.e., setting a quit date, limiting smoking) (Schoenaker et al., 2018), intention

to quit (Brown et al., 2009; Hammond et al., 2006; Hosking et al., 2009), and prioritization of quitting (Schoenaker et al., 2018). Since conversations about smoking harms and quitting are associated with quit attempts, network smoking disapproval may also predict these conversations.

Given the competing evidence suggesting network smoking disapproval could have a positive, negative, or no association with conversations about smoking and cessation, I propose an exploratory hypothesis: The number of alters that disapprove of smoking will be associated with the likelihood of having conversations about smoking and cessation with alters (H1.5.; See Table 2.1).

Descriptive network smoking norms and cessation conversations. In the current study, descriptive smoking norms are operationalized as the number of egocentric network alters who currently smoke. Smokers who have more smokers in their networks have more difficulty quitting smoking (Blok, de Vlas, van Empelen, & van Lenthe, 2017; Hitchman, Fong, Zanna, Thrasher, & Laux, 2014; Thomas et al., 2019). Since conversations about cigarette labeling messages predict quitting (Lambert et al., 2020; Morgan et al., 2018; Thrasher et al., 2016), more network smokers may also result in fewer conversations about smoking and cessation.

Having more network smokers could also lead to more conversations about smoking and cessation. Pictorial warning label studies have found that smokers talk more often about these messages with smokers than with non-smokers (Hall et al., 2015; Morgan et al., 2017), though the smoking status of discussants varied by topic (Hall et al., 2015). Smokers could seek smoking ties as discussants since the topics of smoking and

cessation may be more relevant to discuss with fellow smokers than with non-smokers. Moreover, the presence of other smokers can trigger smokers to light up a cigarette (Shapiro, Jamner, Davydov, & James, 2002; Shiffman et al., 2002). In the current study, participants were exposed to the cessation messages on their packs during their smoking sessions. Being around smoking alters could have triggered participants to start a smoking session, which may have prompted them to share the messages on their packs while they were smoking. This shared exposure to the labels may have led to conversations about smoking and cessation. Given the competing evidence, I propose an exploratory hypothesis for the relationship between network smokers and conversations about smoking and cessation: The number of network smokers will be associated with the likelihood of having conversations about smoking and cessation with alters (H1.6; See Table 2.1).

Having former smokers in one's network appears to promote cessation (Aschbrenner et al., 2018; Burgess-Hull, Roberts, Piper, & Baker, 2018; Schoenaker et al., 2018; van den Putte et al., 2005). Indeed, Christakis's and Fowler's study on network smoking found that clusters of smokers tended to quit smoking together, and smokers were more likely to quit when family and friends also quit smoking (Christakis & Fowler, 2008). Similarly, Schoenaker et al. (2018) found that smokers who lived with someone who had recently quit were more likely to set a quit date and to limit their smoking (Schoenaker et al., 2018). Because conversations about antismoking messages and smoking cessation predict quitting, having a close alter who is a former smoker may predict these conversations. Furthermore, Mario Small's work on the mobilization of networks found that people discuss important matters with network members they

consider to have expertise on or relevance to the topic being discussed (Small, 2013). Thus, smokers may seek advice from former-smoking alters because of the experience those alters have in quitting smoking. Moreover, former-smoking alters may offer unsolicited advice on smoking cessation, even when smokers do not seek their advice. Indeed, literature on social support, social control, and informal advice demonstrates that received support and advice is often unsolicited (Deelstra et al., 2003; Thoits, 2011; Umberson et al., 2010). Unsolicited advice is especially common among close alters (Feng & Magen, 2016). I hypothesize that, compared to participants with no former smokers in their network, participants with at least one former smoker in their network will be more likely to have conversations about smoking and cessation with alters. (H1.2.; See Table 2.1).

Having a spouse or significant other

Trials of pictorial health warning labels on cigarette packs have found that between 34% to 42% smokers talk to spouses about the warnings (Hall et al., 2015; Morgan et al., 2017) and that spouses and significant others are one of the most common conversation partners in these conversations, with 15% of all discussion partners being significant others or spouses (Ramanadhan et al., 2017). This percentage is substantial considering people (typically) have one significant other but multiple alters in other relational roles (e.g., friends, siblings, parents). Spouses and significant others often live in the same home, communicate frequently, and are emotionally close relative to network alters with other roles. Hence, smokers with a spouse or significant other will have an alter they likely see frequently and talk to about personal matters, including their health, which may encourage conversations about smoking and cessation. I hypothesize that,

compared to participants who did not report a spouse or significant other in their network, participants with a spouse or significant other in their network will be more likely to have conversations about smoking and cessation with alters (H1.3; See Table 2.1).

Aim 1 conceptual model and hypotheses

The figure and table below represent the relationships that were assessed in the analysis for Aim 1 of this dissertation.

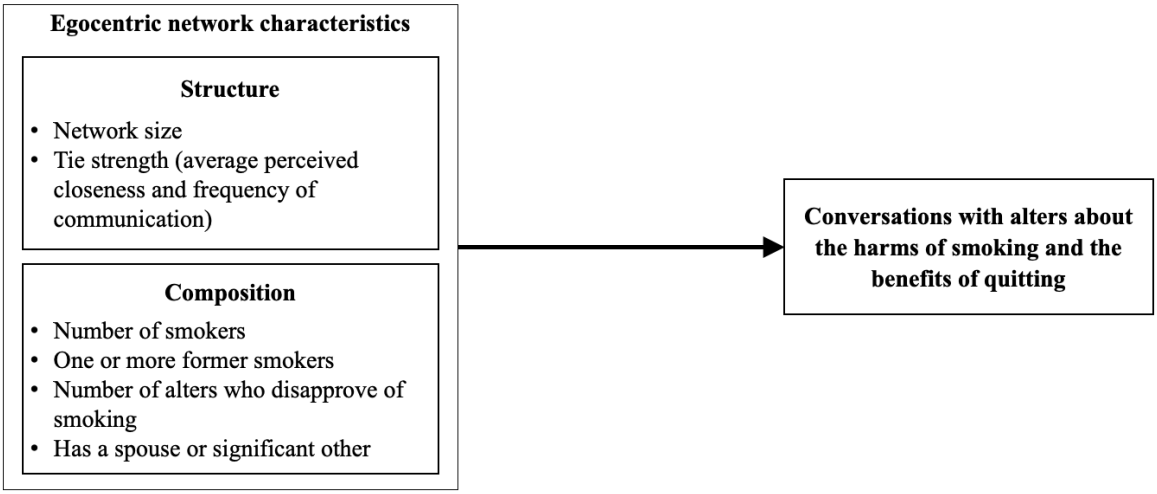

Figure 2.1 Aim 1 conceptual model

Table 2.1 Specific Aim 1 and hypotheses

Specific Aim 1: To assess associations between the characteristics of egocentric networks and the likelihood of having conversations with network alters
Overall hypothesis for Aim 1: Network attributes will influence the likelihood of conversations about smoking harms and cessation benefits with network alters
Hypotheses
H1.1. Network size will be positively associated with the likelihood of having conversations about smoking and cessation with alters.
H1.2. Compared to participants with no former smokers in their network, participants with at least one former smoker in their network will be more likely to have conversations about smoking and cessation with alters.

H1.3. Compared to participants who did not report a spouse or significant other in their network, participants with a spouse or significant other in their network will be more likely to have conversations about smoking and cessation with alters.
Exploratory hypotheses
H1.4. Tie strength (average perceived closeness and baseline frequency of communication) will be associated with the likelihood of having conversations about smoking and cessation with alters.
H1.5. The number of alters that disapprove of smoking will be associated with the likelihood of having conversations about smoking and cessation with alters.
H1.6. The number of network smokers will be associated with the likelihood of having conversations about smoking and cessation with alters.

Background part 2: Aim 2 (To assess the associations of socioeconomic status with egocentric network attributes and the frequency of conversations with network alters)

Socioeconomic status (SES), interpersonal communication, and information seeking

Studies in the U.S. (Lambert et al., 2020) and other countries (Thrasher et al., 2016) have found level of education is positively associated with reporting conversations about cigarette warning labels. Moreover, one study among Australian smokers who recalled antismoking TV advertisements found that, compared to smokers with less than 12 years of education, smokers with a post-secondary level of education were more likely to report talking about quitting as a result of seeing those ads (Dunlop et al., 2014). However, another study in Australia found no relationship between level of education and conversations about antismoking TV ads (Brennan, Durkin, Wakefield, & Kashima, 2017). Higher education also predicts conversations about health topics besides smoking cessation (Geary et al., 2007), conversations about important matters (Bearman & Parigi, 2004; Brashears, 2011), and having more people available to discuss important matters (Bearman & Parigi, 2004; Brashears, 2011; Hampton, Sessions, & Her, 2011). Likewise,

multiple studies have found education is positively associated with the size of discussion networks (i.e., a commonly measured network generator that asks respondents to name the people with whom they have discussed important matters in the last six months) (Andersson, 2018; Brashears, 2011; Hampton et al., 2011; Huang & Tausig, 1990; Marsden, 1987; McPherson, Smith-Lovin, & Brashears, 2006).

There is less evidence for the relationship between income and conversations about smoking cessation and other important topics. One study in the U.S. found income was positively associated with reporting conversations about cigarette warning labels (Lambert et al., 2020). Another study found a similar relationship in Australia, but not in Mexico or Canada (Thrasher et al., 2016). In studies on cessation messages delivered through other mediums, income has not been associated with conversations about those messages. Two evaluations of antismoking TV advertisements in Australia found no association between smoker income and frequency of conversations about the advertisements (Brennan et al., 2017; Dunlop et al., 2014). Similarly, among a large nationally representative U.S. sample, income was positively associated with discussion network size, but it was unassociated with discussions about important matters and with being socially isolated (Brashears, 2011).

The literature on SES, interpersonal communication, and discussion networks suggests people with lower education and income discuss important matters less often and have fewer people with whom they can discuss important topics. Compared to education, there is less evidence that income is associated with interpersonal discussions about cessation, health, and other important topics, which could be because education is more consistently associated with health behaviors than income (Elo, 2009).

In addition to having fewer conversations about health and other important topics, people with lower SES also receive less social support. People with lower income and education report lower levels of various types of social support, including financial (Lubbers, Small, & García, 2020; Schafer & Vargas, 2016), instrumental, emotional, and informational support (Schafer & Vargas, 2016; Weyers et al., 2008). People with lower SES also report having fewer social ties who have helped or could help in times of need (Aartsen, Veenstra, & Hansen, 2017; Schafer & Vargas, 2016) and are less likely to have a trusted and close confidant (Weyers et al., 2008).

The associations between SES and support are similar in research among smokers. Compared to lower SES smokers, higher SES smokers report receiving more cessation-specific social support and social pressure for quitting during quit attempts (Pisinger, Aadahl, Toft, & Jørgensen, 2011; Royce, Corbett, Sorensen, & Ockene, 1997; Sorensen, Emmons, Stoddard, Linnan, & Avrunin, 2002; Thomas et al., 2019; Twyman, Bonevski, Paul, & Bryant, 2014). Moreover, some research suggests low levels of social support and social integration mediate the relationship between SES and smoking status or cessation (Businelle et al., 2010; Cutler & Lleras-Muney, 2010; Mulder, De Bruin, Schreurs, Van Ameijden, & Van Woerkum, 2011). However, one study found that, compared to smokers with higher levels education, lower educated smokers expected more social support for quitting (Meijer, Gebhardt, Van Laar, Kawous, & Beijk, 2016), suggesting a discrepancy in anticipated versus received cessation support among less educated smokers.

In summary, SES appears to be positively associated with conversations sparked by antismoking messages, and people with higher SES report higher levels of various

types of social support, including cessation-specific support among smokers. Therefore, I hypothesize that participant income and education in the current study will be positively associated with the frequency of conversations about smoking and cessation with alters (H2.1 and H2.2; See Table 2.2).

SES and social influences on smoking

Literature reviews of smoking and cessation inequities by SES have consistently documented the social environment as a mechanism of these inequities. Lower SES smokers have more difficulty seeking and accessing cessation treatment and initiating and adhering to quit attempts because of high pro-smoking norms and low general and cessation-specific social support (Hiscock, Bauld, Amos, Fidler, & Munafò, 2012; Twyman et al., 2014; van Wijk, Landais, & Harting, 2019; Weyers, Dragano, Richter, & Bosma, 2010). While social factors clearly account for much of the SES disparities in smoking and cessation, more research is needed to better understand how the attributes of smokers' social networks lead to these disparities, including differences in interpersonal conversations about smoking and cessation, a consistent predictor of quit attempts.

No studies have assessed the mechanisms for SES differences in social interactions that encourage cessation. Differences by SES in the frequency of cessation conversations may be in part explained by the attributes of smokers' social networks, including social influences associated with smoking outcomes in prior studies as well as other well-documented network differences by SES. However, the only study that has used social network methods to assess these conversations was only among smokers with low income and education and did not assess associations between network

characteristics and conversations (Ramanadhan et al., 2017). Therefore, it is unknown whether social network characteristics contribute to differences in conversations about smoking and cessation by SES. This dissertation will begin to answer this question.

SES and injunctive smoking norms (social approval of smoking)

Compared to high SES smokers, low SES smokers report less social pressure to quit smoking (Royce et al., 1997; Sorensen et al., 2002) and appear to experience fewer social consequences for continuing to smoke (Christakis & Fowler, 2008; Paul et al., 2010). Moreover, low SES smokers report feeling explicit social pressure to continue smoking (Stead, MacAskill, MacKintosh, Reece, & Eadie, 2001). Qualitive research also indicates that socioeconomically disadvantaged smokers perceive their social environments to be more accepting of smoking than do more advantaged smokers (Paul et al., 2010). In these studies, disadvantaged smokers described social contexts in which smoking is normalized and accepted and cessation is often discouraged (Paul et al., 2010; Stead et al., 2001; Wiltshire, Bancroft, Parry, & Amos, 2003). Perceptions of smoking acceptance among less advantaged smokers appear linked to high levels of community and network smoking, ease of accessibility of cigarettes, and work and leisure settings that are conducive to smoking (Paul et al., 2010; Stead et al., 2001; Wiltshire et al., 2003). Disadvantaged smokers describe all of these social and environmental influences as major barriers to quitting (Stead et al., 2001; Wiltshire et al., 2003).

Perceived social acceptability of smoking is associated with cessation related outcomes (Brown et al., 2009; Hammond et al., 2006; Hosking et al., 2009; Rennen et al., 2014; Schoenaker et al., 2018). However, few studies have directly compared perceived

smoking approval by SES. Two studies suggest that, compared to higher SES smokers, lower SES smokers perceive higher social acceptability of smoking (Hammond et al., 2006; Sorensen et al., 2002). However, another study found that, while perceived smoking *disapproval* was less common among low versus high SES smokers, this difference was not significant (Schoenaker et al., 2018); this could be because the study was conducted in Australia, where strong tobacco control measures have increased antismoking norms across SES levels. That study also found that antismoking norms were more strongly associated with quitting behaviors among lower SES smokers, suggesting that social influence is more impactful among disadvantaged smokers (Schoenaker et al., 2018).

Though there is a paucity of studies explicitly comparing smoking approval by smoker SES, evidence suggests that lower SES smokers are exposed to social contexts more accepting of smoking. Therefore, I hypothesize that participant SES (income and education) will be positively associated the number of alters disapproving of smoking (H2.3; See Table 2.2).

In addition to the lack of research comparing injunctive smoking norms by SES, no published studies to my knowledge have assessed whether injunctive norms mediate the relationship between SES and cessation-related outcomes or responses to cessation interventions. More research is needed to understand if injunctive norms influence SES differences in interpersonal predictors of quitting, such as conversations about smoking and cessation.

If network smoking acceptability is higher among lower SES smokers in the proposed study, this may partially explain the relationship between SES and conversations about smoking and cessation. There is strong evidence that injunctive norms influence cessation outcomes (Brown et al., 2009; Hammond et al., 2006; Hosking et al., 2009; Rennen et al., 2014; Schoenaker et al., 2018). Furthermore, in qualitative studies, disadvantaged smokers have described social and environmental influences as major barriers to quitting (Stead et al., 2001; Wiltshire et al., 2003), while higher SES smokers described their social environments as less accepting of smoking (Paul et al., 2010). However, injunctive norms may not influence conversations in the same way that they affect other cessation-related outcomes. As described above in the background for Aim 1, evidence suggests the relationship between injunctive smoking norms and conversations about smoking and cessation could be positive or negative. Therefore, I propose an exploratory hypothesis: The number of alters that disapprove of smoking will mediate the relationship between participant SES and the frequency of conversations about smoking and cessation with alter. (H2.6; See Table 2.2).

SES and descriptive smoking norms (smoking prevalence)

Descriptive smoking norms, or the prevalence of smoking in one's social environment, also influence smokers' ability to quit (Blok et al., 2017; Hitchman, Fong, Zanna, Thrasher, & Laux, 2014; Thomas et al., 2019). In this dissertation, descriptive norms are measured at the network level; therefore, the following review of the literature on descriptive norms will describe studies on network smoking (i.e., network descriptive norms) and its association with SES.

Smokers with lower income and education have more smokers in their social networks (Hitchman, Fong, Zanna, Thrasher, Chung-Hall, et al., 2014; Honjo, Tsutsumi, Kawachi, & Kawakami, 2006; Thomas et al., 2019). Moreover, one study found education was more strongly associated with network non-smokers than with network smokers, suggesting that higher SES smokers have a higher proportion of network non-smokers (Meijer et al., 2016). However, Schoenaker et al. (2018) found smokers' SES was positively associated with number of quitters in the household but that this relationship was not statistically significant.

Research on network smoking by SES reflects research on network homophily by SES. Across social strata, people tend to have and form relationships with others similar to themselves, a phenomenon known as the homophily principal (Marsden, 1988; McPherson, Smith-Lovin, & Cook, 2001). People with lower SES have disproportionately homophilous networks on various characteristics, including education (Marsden, 1988; J. A. Smith, McPherson, & Smith-Lovin, 2014), age, sex, and religion (Campbell, Marsden, & Hurlbert, 1986). In short, compared to people with higher SES, people with lower SES tend to have networks comprising people more similar to themselves. Hence, as the studies on SES and network smoking suggest, lower SES smokers should have higher levels of smoking in their networks (i.e., network smoking homophily). I hypothesize that participant SES (income and education) will be negatively associated with the number of network smokers (H2.4; See Table 2.2).

While lower SES smokers report high prevalence of network or community smoking as a barrier to cessation (Pisinger et al., 2011; Twyman et al., 2014), evidence is mixed on whether smoking among network members mediates the relationship between

SES and cessation-related outcomes. For example, one study found that exposure to other smokers mediated the relationship between SES and a smoking lapse during a quit attempt (Cambron, Lam, Cinciripini, Li, & Wetter, 2019). However, another study found that household smoking but not friend smoking mediated the association between SES and cessation (Honjo et al., 2006). Hence, the relationship and proximity to other smokers may be more important for influencing cessation among low SES smokers than the absolute number of smokers in their networks. Indeed, social influence theory (Latané, 1981) suggests that proximity and strength of relationships are key to understanding the social influence of network members on behaviors.

Given the mixed evidence that descriptive norms mediate the relationship between SES and cessation, and because there is competing evidence suggesting both a positive and negative relationship between network smoking and frequency of conversations (see background for Aim 1), I propose an exploratory hypothesis: The number of network smokers will mediate the relationship between SES and the frequency of conversations with alters. (H2.7; See Table 2.2).

SES and network size

In addition to network smoking norms, other SES differences in network characteristics may affect conversations about smoking and cessation. One of the most well documented network differences by SES is network size. Cross-sectional studies have found that people with few financial resources have smaller networks, though the strength of this association varies by setting as well as the socioeconomic and network measures used (Albert & Hajdu, 2020; Huang & Tausig, 1990; Schafer & Vargas, 2016;

Tigges, Browne, & Green, 1998). Studies suggest that people with fewer financial resources may have smaller networks because of lower participation in formal social settings (e.g., work, school, leisure activities) (Petev, 2013; van Eijk, 2010). Socioeconomic pressure can also strain relationships, potentially eroding social relationships in the networks of people with low income (Lubbers, García, et al., 2020; Lubbers, Small, et al., 2020; Offer, 2012).

Evidence is more robust for the relationship between education and network size. Multiple studies in the U.S. have found that education is positively associated with the size of important discussion networks (Andersson, 2018; Brashears, 2011; Huang & Tausig, 1990; Marsden, 1987; McPherson et al., 2006; Tigges et al., 1998). Education is also positively associated with the size of other types of egocentric networks (Ajrouch, Blandon, & Antonucci, 2005; Schafer & Vargas, 2016). One older study found no association between education or income and the size of close networks; however, there were serious limitations to the network data in that study that make it difficult to compare with other network studies (Pugliesi & Shook, 1998).

Research using other SES indicators, such as social class and occupation, have likewise found that people with lower SES tend to be more socially isolated (Petev, 2013) and recall smaller networks in times of need (E. B. Smith, Menon, & Thompson, 2012). People with lower social status also tend recall more interconnected (i.e., redundant) network members in times of need (E. B. Smith et al., 2012). Therefore, people with lower SES may have especially limited networks during the times they most require resources and support. Because of the abundance of evidence that SES indicators are

positively associated with network size, I hypothesize that participant SES (income and education) will be positively associated with network size (H2.5; See Table 2.2).[3]

Given the evidence suggesting a positive association between SES and network size and a positive association between network size and conversations about smoking and cessation (see Aim 1 background), I hypothesize that network size will mediate the relationship between SES and the frequency of conversations about smoking and cessation with alters (H2.8; See Table 2.2).

Additional theoretical considerations for Aim 2

While various theories informed the Aim 2 hypotheses about the specific relationships between SES and network variables, one theory more broadly underlies the entire conceptual model for Aim 2. The theory of fundamental causes (ToFC) posits that SES is associated with health behaviors and health status through social and structural conditions (Link & Phelan, 1995). While this theory proposes the mechanisms for the relationship between SES and health change over time, there are always upstream social and structural factors linked to SES that influence downstream individual-level factors, such as knowledge, behaviors, and disease outcomes (Link & Phelan, 1995). Building on the principal of fundamental causes, Berkman posits that social-structural factors, such as

[3] Though income, education, and other SES indicators have been positively associated with network size in prior research, the name generator used in this dissertation could result in a negative or null relationship between SES and network size. The name generator in this study asked egos to name alters with whom they felt the closest and spent the most time. Hence, the networks in this dissertation should be characterized by very high tie strength. Compared to people with higher SES, those with lower SES socialize more often with network members (Aartsen et al., 2017; Campbell et al., 1986; Huang & Tausig, 1990; Schafer & Vargas, 2016) and have ties whom they have known longer. One study also suggested people with lower SES have more ties they perceive as close (Weyers et al., 2008). Because the name generator in the proposed study sought to elicit strong ties, lower SES smokers in our study may have named more alters than higher SES smokers.

socioeconomic inequities, shape social network structures and characteristics (Berkman & Krishna, 2015). Social networks in turn influence psychosocial factors – such as social support, influence, and interactions– which, in turn, shape individuals' attitudes and behaviors (Berkman & Krishna, 2015).

The pathways outlined by ToFC and other related work (e.g., Berkman et al. (2014)) informed the hypothesized mediating relationships in Aim 2 of this dissertation. Social network characteristics may plausibly influence or have a reciprocal relationship with SES. However, ToFC and related work demonstrate SES is a fundamental cause of health outcomes and that social network factors mediate the relationship between SES and health behaviors and outcomes. Moreover, it is unlikely that the social network characteristics in the conceptual model for Aim 2 influence conversations about smoking and cessation through smokers' SES. Thus, in my Aim 2 conceptual model, I propose that the relationships between SES and network characteristics are uni-directional, with SES influencing network characteristics, and not the other way around. Furthermore, social factors– such exposure to smoking (Cambron et al., 2019; Hiscock et al., 2012, 2011; Jahnel, Ferguson, Shiffman, Thrul, & Schüz, 2018; van Wijk et al., 2019) and social support (van Wijk et al., 2019)– mediate the relationship between SES and smoking and cessation. Therefore, I make the case that SES affects the structure and attributes of smokers' networks, which, in turn, influence conversations about smoking and cessation.

Aim 2 conceptual model and hypotheses

The figure and table below represent the relationships that were assessed in the analysis for Aim 2 of this dissertation.

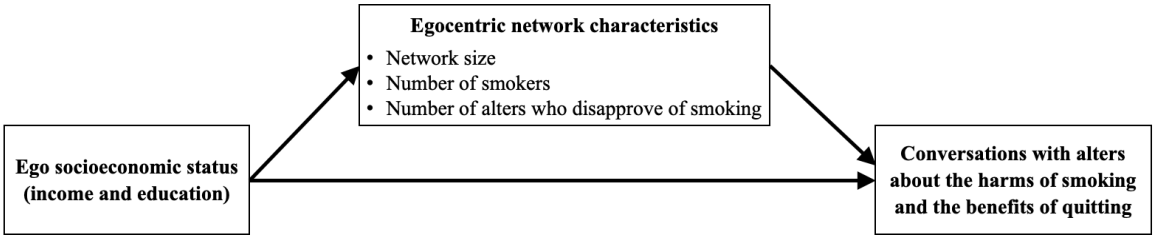

Figure 2.2 Aim 2 conceptual model

Table 2.2 Specific Aim 2, hypotheses, and research questions

Specific Aim 2: To assess the associations of socioeconomic status with egocentric network attributes and the frequency of conversations with network alters
Overall hypothesis for Aim 2: Socioeconomic status will influence network attributes, which will, in turn, influence the frequency of conversations about smoking harms and cessation benefits with alters.
Hypotheses related to SES and conversations with alters
H2.1. Participant income will be positively associated with the frequency of conversations about smoking and cessation with alters.
H2.2. Participant education will be positively associated with the frequency of conversations about smoking and cessation with alters.
Hypotheses related to SES and network characteristics
H2.3. Participant SES (income and education) will be positively associated with the number of alters disapproving of smoking.
H2.4. Participant SES (income and education) will be negatively associated with the number of network smokers.
H2.5. Participant SES (income and education) will be positively associated with network size.
Hypothesis related to mediation of the relationships between SES and conversations by network characteristics
H2.6. The number of alters that disapprove of smoking will mediate the relationship between participant SES and the frequency of conversations about smoking and cessation with alters.

H2.7. The number of network smokers will mediate the relationship between SES and the frequency of conversations with alters.
H2.8. Network size will mediate the relationship between SES and the frequency of conversations about smoking and cessation with alters.

Significance

Aim 1 of this dissertation is to assess associations between the attributes of smokers' egocentric networks and the likelihood of having conversations with network alters. The results from this aim will contribute to the field of public health in several ways. First, this research will provide the most comprehensive analysis to date of the social factors influencing conversations about smoking and cessation. There has been limited research on the characteristics of discussants in these conversations, and no studies have assessed the social network attributes that predict them.

Second, by assessing relationships between network characteristics and conversations that occur in the context of exposure to cessation messages, this dissertation will elucidate social network characteristics that promote or prohibit interpersonal sharing and processing of cessation messages and support. Clarifying how network characteristics influence conversations about smoking harms and cessation may help identify strategies that best leverage networks to disseminate, enhance, and sustain the effects of cessation communication interventions (Valente, 2011; Valente & Pitts, 2017). Specifically, understanding the characteristics of networks that encourage conversations about smoking and cessation can point to the characteristics of network alters that might be best targeted in interventions seeking to engage smokers' networks in cessation efforts.

Finally, the results from Aim 1 may generate hypotheses for future studies that further examine conversations about smoking and cessation. Subsequent studies with larger sample sizes could investigate why and how smokers and their network members initiate these conversations, the content of the conversations, and how the effects of conversations vary by the characteristics of social networks. Ultimately, this line of research will inform interventions that both help smokers seek support and assist their network members in providing support in their efforts to quit. For example, if networks comprised of non-smokers best encourage conversations that lead to quitting, future interventions could help non-smokers be a better resource to smokers by encouraging them to have more conversations with supportive content.

Aim 2 of this dissertation is to assess associations between socioeconomic status, egocentric network attributes, and the frequency of conversations about smoking and cessation with network alters. The results of this aim will improve understanding of SES differences in conversations about smoking and cessation in the context of novel cessation messages on cigarette packs. Research on SES differences in the effects of cigarette pack messages has been mostly been cross-sectional and focused on individual-level outcomes, including affective (Bekalu et al., 2018; Gibson et al., 2015) and cognitive reactions (Bekalu et al., 2018; Cantrell et al., 2013; Gibson et al., 2015; Hammond et al., 2012; Swayampakala, Thrasher, Yong, et al., 2018; Thrasher et al., 2010). Only two studies have reported SES differences in interpersonal reactions to these messages, these studies suggest smokers with lower income and education are less likely to discuss cigarette warning labels (Lambert et al., 2020; Thrasher et al., 2016). However, no studies have assessed SES differences in these conversations immediately after

exposure to new cessation messages or investigated the mechanisms of these differences. Because there is much evidence that social factors such as low social support and high pro-smoking norms contribute to SES disparities in smoking and cessation, social network characteristics are likely to mediate the relationship between SES and conversations about smoking and cessation. The analysis for Aim 2 of this dissertation will be the first study to compare conversations about smoking and cessation by SES during repeated exposure to novel cessation messages on and inside cigarette packs. Evaluating conversations in "real time" under conditions of repeated exposure to messages represents an important opportunity to understand these relationships. It will also provide the first investigation of the mechanisms for SES differences in conversations about smoking and cessation.

The findings from Aim 2 may also illuminate how social network characteristics could impede cessation-related discussions for smokers with lower income and educational attainment. Indeed, understanding the relationship between social network characteristics, SES, and interpersonal communication about smoking and cessation may more broadly shed light on why lower SES smokers have a harder time quitting. These findings may be relevant outside of smoking cessation, as well, because the network attributes that contribute to SES differences in conversations about smoking and cessation may also contribute to differences in conversations about other health topics. Furthermore, results from Aim 2 may inform interventions that consider the structure and characteristics of social networks (e.g., addressing the effects of network homophily and isolation among low SES populations) and more upstream interventions to eliminate SES disparities in smoking cessation and other health behaviors.

Overall, the results from this dissertation will help reveal the social network contexts that may encourage conversations about smoking and cessation and lead to differences in conversations by SES. This information can guide future communication and social network interventions so that they spark more frequent and effective conversations about smoking and cessation, ideally in ways that reduce health disparities in cessation outcomes. Because conversations about cessation messages and other smoking-related topics are associated with quitting (Jeong et al., 2015; Lambert et al., 2020; Morgan et al., 2018; Ramanadhan et al., 2017; Thrasher et al., 2016; van den Putte et al., 2011), increasing these conversations among low SES smokers in particular may help enhance and sustain the effects of cessation interventions and reduce disparities in their impacts, ultimately reducing the burden of death and disease from smoking.

Chapter 3

Research Design and Methods

Overview

The overall goal of this dissertation is to investigate the relationship between network characteristics and conversations about smoking and cessation, including the role of networks in SES disparities in these conversations. The specific aims that will contribute to this goal are: 1) To assess associations between the characteristics of egocentric networks and the likelihood of having conversations about smoking and cessation with network alters and 2) To assess the associations of socioeconomic status with egocentric network attributes and the frequency of conversations about smoking and cessation with network alters.

The data for this dissertation come from a 2X2 randomized, between-subject cigarette labeling trial among 367 adult cigarette smokers in the United States. Participants in this trial provided information about their egocentric social networks at study baseline. Then, once per day over the course of 14 days, participants reported conversations about smoking harms and quitting benefits with their network alters.

Overall conceptual model

There are three conceptual models for the proposed dissertation. Figure 3.1 is the overall conceptual model, which demonstrates all the relationships that will be assessed

in this dissertation. The aim-specific models shown in Chapter 2 (see Figure 2.1 and Figure 2.2) are nested within the overall conceptual model represented in Figure 3.1 below.

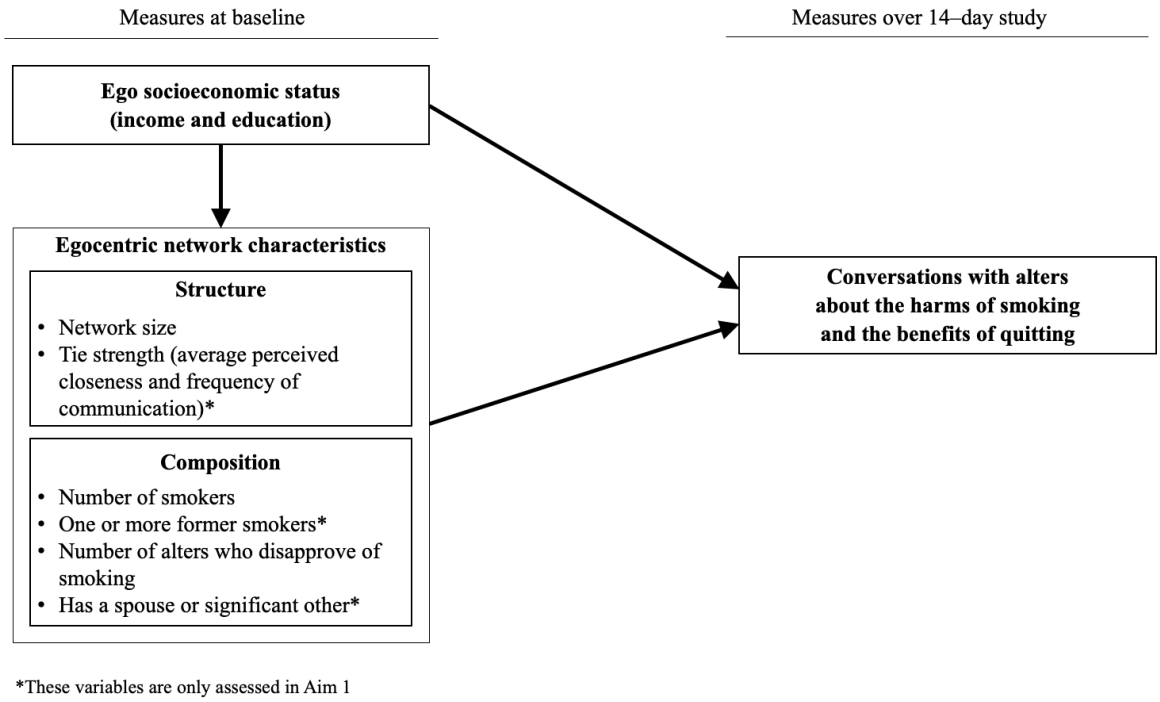

Figure 3.1 Overall conceptual model

Study design

The design for this study is a repeated measures, longitudinal, observational study. The data for this dissertation come from a between-subject randomized controlled trial among US adult smokers. Participants in this study were given a 14-day supply of their preferred cigarette brand variety with packs modified to reflect their experimental condition (i.e., text-only warnings labels, inserts with efficacy messages, pictorial warning labels, and efficacy inserts and pictorial labels). At baseline, participants named up to 5 people with whom they felt close and had interacted with frequently (i.e., alters)

and reported several attributes of these people. For 14 days, participants completed surveys each evening that asked them to report conversations they had in the prior 24 hours about smoking harms and quitting benefits with these network alters.

The parent study for this project found mostly null effects of treatment on cessation-related outcomes, including conversations about smoking harms or cessation benefits. This was likely due to insufficient power to detect these effects (Thrasher et al., in press). Therefore, I considered message condition a control variable rather than a primary predictor of conversations. See the section below on rationale for measures and study design for a more detailed justification.

Sample and recruitment

Data collection began on June 28th, 2019 and continued until July 6th, 2021, spanning periods before and during the COVID-19 pandemic. Participants were recruited from South Carolina, North Carolina, and New York state. Adult smokers (i.e., ≥18 years old) were eligible if they spoke and read English, reported smoking at least 100 cigarettes in their lifetime and at least 10 cigarettes each day in the prior month. Smokers who used other nicotine products in the prior month were ineligible due to challenges around assessing compensatory behaviors involving use of other nicotine products when reducing cigarettes. Beginning in January 2020, the minimum age to participate was increased to 21 due to the implementation of a federal policy that raised the legal age for purchasing tobacco to 21. Target quotas were used for education (50% <=high school; 50% > high school) and sex (50% male; 50% female), though these were relaxed due to delays and challenges in participant recruitment after the onset of COVID-19.

Multiple recruitment methods were used to ensure variability in participant SES. In the pre-COVID-19 recruitment period (i.e., July 2019 to March 2020), two recruitment methods were used. A mobile lab targeted low SES smokers by recruiting outside smoke shops in low-income neighborhoods in different cities across central New York state (Binghamton, Cortland, Ithaca, Newark, Oswego, and Syracuse). City-level census data were used to identify areas where the median household income was lower (median incomes ranged from $34K - $44K) than the state median ($68K). Sites were then selected from the list of candidates based on driving distances, the presence of smoke shops that were willing and capable of hosting the mobile lab (i.e., had sufficient adjacent parking), and conversations with shopkeepers about their patrons. One week before data collection, flyers were placed in targeted smoke shops where the lab would be stationed for one to two days for intercept recruitment with smoke shop patrons. In Columbia, SC, ads in social media and flyers in public places were used. Screening for eligibility was done in person, online, or by phone, depending on recruitment modality.

During the COVID-19 study period (i.e., August 2020 to June 2021), all participants were recruited through social media targeted to specific areas (e.g., Columbia and Greenville, SC and Charlotte, NC; Binghamton, Cortland, Elmira, Rochester, Utica, and Syracuse, NY). Screening was done both online and by telephone to schedule the time and place where participants could receive study materials (e.g., cigarette packs, study smartphone). After eligibility was assessed, all participants provided informed consent, which was done in person with a physical consent document and signature before COVID-19 and through an online form and signature during COVID-19.

Procedures

The University of South Carolina's institutional review board approved the study procedures before data collection began. Prior to the outbreak of COVID-19, participants completed an online baseline survey, in-person baseline interview (including social network assessment), and in-person study training during their visit to the mobile lab in NY or, for SC participants, during a scheduled visit to a lab at a university. During the COVID-19 period, all in-person data collection and training ended. Thus, after the pandemic, the social network variables were assessed in telephone calls that occurred after eligibility was confirmed. A link to the baseline survey was then emailed to participants, and participant training in study protocols took place virtually using Zoom. COVID-19 protocols did not allow for collecting CO to confirm smoking status.

It is important to note that the method of social network assessments changed from in-person interviews in the pre-COVID-19 period to telephone interviews in the post-COVID-19 period. Evidence suggests that face-to-face and telephone interviews are similarly reliable for assessing egocentric network characteristics, especially for questions about network tie behaviors (e.g., alter smoking) (Kogovšek & Ferligoj, 2005). However, face-to-face interviews produce less valid results than telephone interviews. (Kogovšek & Ferligoj, 2005). Furthermore, network size appears to vary by data collection mode, with larger networks generated during telephone interviews than face-to-face interviews (Kogovšek, Ferligoj, Coenders, & Saris, 2002).

In both pre- and post-COVID-19 periods, after participants completed the baseline assessments and training, they immediately began the EMA study period. For 14

days, participants received nightly surveys on mobile phones provided to them. Check-in calls with study staff occurred on days 3 and 6 of the EMA period to ensure participant understanding of the protocols, with additional calls for those who did not appear to be following protocols based on the review of real-time survey data.

Message conditions

Participants were randomized to receive one of four message conditions (i.e., text-only warnings labels, inserts with efficacy messages, pictorial warning labels, and efficacy inserts and pictorial labels), which were applied to the cigarettes packs they used during the 14-day EMA data collection period. Efficacy insert message content was based on prior studies (Loud, Lambert, Porticella, Niederdeppe, & Thrasher, 2021; Thrasher, Anshari, et al., 2018; Thrasher, Islam, et al., 2018), with two messages about cessation benefits and two with cessation tips appropriate for primary school reading levels (range=4.6-5th grade). Inserts were printed on 2" x 3.5" glossy cards (16 pt. matte, like business cards) with legible font and placed inside packs, between the external packaging and the foil that covers cigarettes. HWL text for all conditions included four messages specified in 2012 for future US implementation (111th Congress, 2009). The text-only "control" condition used the current US HWL size and placement (i.e., 50% of one pack side), whereas the pictorial HWLs were 2" x 1.75" and placed on the lower half of both the front and back of packs, with imagery selected based on prior research (Brewer et al., 2016; Evans et al., 2015; Hammond, Reid, Driezen, & Boudreau, 2013; Hammond et al., 2012; Thrasher et al., 2012). Insert and HWL messages were placed systematically in and/or on packs provided to participants, so that most participants

would be exposed to each message multiple times, with the frequency depending on how much they smoked.

Rationale for measures and study design

In this dissertation, the measures of conversations did not explicitly ask about conversations about the cigarette package labels. Instead, they more broadly assessed conversations about smoking harms and cessation. This was purposeful, as the investigators wanted to reduce the likelihood of bias due to treatment by testing interactions. That is, the investigators did not want to prompt participants to think about the cigarette labeling messages by constantly asking them about the messages in the daily surveys. Nevertheless, the measures in this study captured conversation topics that prior research has shown are increased after exposure to novel antismoking messages and are also important for encouraging cessation outcomes. Therefore, the results of this dissertation will have implications for future research and interventions on conversations sparked by cessation messages, and, more broadly, by conversations not sparked by messages.

The study from which the data are derived exposed all participants to novel messages about the harms of smoking on their packs, with approximately half also receiving cessation messages inside their cigarette packs. While the study was designed with four distinct message conditions that the investigators expected to have different effects on cessation outcomes, I did not focus on the effects of message condition in my analyses. The parent study found no effect of message condition on conversations about the harms of smoking or the benefits of quitting as well as several other cessation-related

outcomes (Thrasher et al., in press). It was likely underpowered to assess many of these effects, especially conversations about smoking and cessation which likely has a much smaller effect size than other cessation-related outcomes given how infrequently these conversations occur. Furthermore, the same four, novel textual messages about smoking-related risks were put on the outside of cigarette packs across all four conditions, and there is some evidence that novel pack messages are associated with increased conversations about the messages (Thrasher et al., 2016). Because this dissertation aims to assess the social network conditions that encourage conversations about smoking harms and cessation benefits, and because the current study is not adequately powered to assess conversation differences between the four message conditions, I analyzed the data as if it was observational. That is, I considered message condition a control variable instead of a primary independent variable in my conceptual models, analyses, and interpretation of the results.

Measures

Network generator (assessed at baseline). To elicit alters, interviewers used a name generator that asked, "Of the people with whom you are closest, who have you spent the most time with in the past two weeks?" Participants could name up to 5 people, as some evidence suggests 5 alters is the ideal number to maximize non-redundant network information while minimizing participant burden in network name generators (Merluzzi & Burt, 2013). Furthermore, because it is unlikely that young children would have discussions about smoking and cessation, participants were not allowed to name children younger than 3 years old.

The purpose of this network name generator was to elicit alters with whom participants felt close and were likely to interact over the two-week study period. Thus, it was both affect-based and interaction-based, which are two popular types of name generators in egocentric network studies (Perry, Pescosolido, & Borgatti, 2018). One advantage of having an affect component is that emotionally closer alters are those most likely to influence participants' attitudes and behaviors ((Burt, 1984) as cited in (Perry et al., 2018)). Moreover, alters generated by self-reports of interaction are highly reliable over time and are most often long-term alters who are both frequently and recently contacted by participants (Marsden, 1990). Other studies have taken a similar approach of combining affect and interaction name generators into a single name generator (cf. (Kitts & Leal, 2021)).

Network characteristics (assessed at baseline). To assess the characteristics of alters, an alter-wise ordering approach was used in which all the characteristics of a single alter were assessed in full before asking questions about the characteristics of the other alters. There is conflicting evidence on whether this approach is superior to question-wise ordering, which is an approach in which a single question is asked about all alters before moving on to the next question. Studies from in-person and telephone interviews suggest alter-wise ordering is similarly valid and more reliable than question-wise ordering (Kogovšek & Ferligoj, 2005; Kogovšek et al., 2002). However, other studies form online surveys suggest question-wise ordering is more valid and reliable and results in less item non-response (Coromina & Coenders, 2006; Vehovar, Lozar Manfreda, Koren, & Hlebec, 2008). For each network variable described below, I created

a network-level average or score for each ego (i.e., study participant). In network analysis, categorical variables can be represented as network proportions or frequencies.

Network size represents the number of alters each participant named in the name generator, with values ranging from 0-5.

Tie strength for each alter was measured with two items. The first item assessed *perceived closeness* and asked participants how close they felt to each alter, with response options ranging from "Not at all close" (1) to "Extremely close" (5). We adapted this item from a Gallup Panel survey that is not publicly available but has been used in published research (e.g., (Pachucki & Leal, 2020; Shakya & Christakis, 2017)). The second indicator of tie strength was *frequency of communication*, which was assessed by asking participants how often they talked to each alter. Response options included "Every day" (1), "Several times a week" (2), "Once a week" (3), "Once every two weeks" (4), "Once a month or less" (5), and "Don't know." We adapted this item from the National Social Life, Health and Aging Project (NSHAP) (Waite et al., 2017). We reverse coded the responses so that higher values represented more frequent interactions. For each network, we generated an average for perceived closeness and for frequency of interactions, and we assessed these two indicators of tie strength as separate variables in all analyses.

Having a spouse or significant other in one's network was derived from an item adapted from the NSHAP (Waite et al., 2017) that asked participants the type of relationship they had with each alter. Response options included, "Spouse", "Partner or significant other", "Parent", "Child", "Other family", "Friend", "Work colleague",

"Neighbor, "Acquaintance", and "Other." Participants could only select one option for each alter. For each network, we created a binary variable to indicate whether each participant named a spouse or significant other (0=Did not name spouse or significant other; and 1=Named spouse or significant other).

The smoking status of each alter was assessed by asking "To the best of your knowledge, does [name of alter] smoke cigarettes?" Response options included "No", "Not now, but used to smoke", "Yes", and "Don't know." For each network, we created a variable that counted the *number of smokers*, that is, the number of alters for which the participant responded "Yes" to the smoking status question (range 0 smokers – 5 smokers). We also created a binary variable to indicate whether each *network had a former smoker*, that is, the participant indicated "Not now, but used to smoke" about 1 or more alters (0= No former smokers; 1=1 or more former smokers).

Smoking approval was assessed for each alter by asking participants, "What does [name of alter] think about your smoking?". Response options ranged from "Strongly disapproves" (1) to "Strongly approves" (5). We developed this item based on the theories of normative conduct (Cialdini et al., 1990) and normative influence (Rimal & Real, 2005) as well as measures of smoking disapproval (injunctive norms) used in prior research (Hammond et al., 2006; Schoenaker et al., 2018; van den Putte et al., 2005). We dichotomized this variable for each alter to indicate disapproval of smoking, with 1= Strongly disapproves or Disapproves and 0 = Neutral, Approves, or Strongly approves. We then created a count for each network of the *number of alters disapproving of smoking* (0 disapprove – 5 disapprove).

Conversations about the dangers of smoking and conversations about the benefits of quitting (assessed in daily EMA surveys). Conversations with alters were assessed in three steps in the daily surveys. First, the survey asked, "In the last 24 hours, have you talked with [list of alters named at baseline] about good or bad things about smoking or quitting?" (0=No, 1=Yes). Second, if a participant selected "Yes", the survey repeated the same question for each alter (e.g., "In the last 24 hours, have you talked with [alter 1] about good or bad things about smoking or quitting?" (0=No, 1=Yes)).[4] Third, for each alter that a participant reported talking with about smoking or quitting, the participant was asked to report what they talked about with that alter. Response options included "How much you like smoking", "Dangers of smoking to you", "Benefits of quitting smoking", "Cigarette pack health messages are informative", "Cigarette pack health messages are NOT believable", "Cigarette pack health messages are useless", and "Other topics." Studies have found that conversations about quitting smoking (Jeong et al., 2015; van den Putte et al., 2011) and conversations that characterize smoking negatively (Ramanadhan et al., 2017) are more strongly associated with cessation outcomes compared to other conversations sparked by cessation messages. Therefore, our analyses only included conversations in which the topics "Dangers of smoking to you" or "Benefits of quitting smoking" were discussed. These two topics were treated as separate dependent variables and coded dichotomously (0=Did not discuss topic on that day; 1=Discussed topic on that day).

[4] To reduce potential bias from prompting participants to think about the cigarette labeling messages by constantly asking them about the messages in the nightly surveys, the measures did not explicitly ask about conversations about the cigarette package labels.

Participant socioeconomic status (assessed at baseline). *Household income* of participants was assessed with an item that asked, "Which of the following categories best describes your ANNUAL household income, that is the total income before taxes, or gross income, of all persons in your household combined, for one year?" Response options included, "Under $10,000", "$10,000-29,999", "$30,000-44,999", "$45,000-59,999", "$60,000-74,999", "$75,000-99,999", "$100,000-149,999", "$150,000 and over", and "Prefer not to answer" (Thompson et al., 2019).

Education of participants was assessed with an item that asked, "What is the highest level of formal education that you have completed?" Response options included, "Grade school or some high school", "Completed high school", "Technical / trade school or community college", "Some university, no degree", "Completed university degree", and "Post-graduate degree" (Thompson et al., 2019). Responses were categorized as low (High school or less), moderate (Technical/trade school or community college or some university), and high (Completed university or post-graduate degree), as in other studies that have used this measure (Hitchman, Fong, Zanna, Thrasher, Chung-Hall, et al., 2014; Reid et al., 2010; Siahpush, Yong, Borland, Reid, & Hammond, 2009; Swayampakala, Thrasher, Hardin, et al., 2018).

Though income and education represent ego socioeconomic status, these two indicators were assessed as separate variables in all analyses for several reasons. First, this approach is consistent with other studies that have used these variables, all of which to my knowledge have assessed them separately (Hitchman, Fong, Zanna, Thrasher, Chung-Hall, et al., 2014; Reid et al., 2010; Siahpush et al., 2009; Swayampakala, Thrasher, Hardin, et al., 2018). Second, given that there has been very little research on

SES differences in interpersonal communication about cessation and smoking, it is important to assess education and income separately to understand if they function differently to affect network characteristics and conversations about smoking and cessation. Third, education and income have different associations with cessation-related outcomes in other research. For example, some studies find education is more consistently associated with quit attempts (Kotz & West, 2009; Reid et al., 2010; United States Department of Health and Human Services, 2014), self-efficacy to quit (Siahpush, McNeill, Borland, & Fong, 2006), and successful quitting (Reid et al., 2010; Ruokolainen et al., 2021).

Control variables (assessed at baseline). *Cigarettes per day* was assessed with an item that asked, "On average, how many cigarettes do you smoke each day, including both factory-made and roll-your-own cigarettes?"

Recent quit attempt was measured by asking smokers if they had attempted to quit smoking in the past year. Recent quit attempts may predict both future quit attempts and conversations about health warning labels (Lambert et al., 2020; Thrasher et al., 2016).

Intention to quit smoking was also assessed, and responses were dichotomized to indicate intention to quit within the next six months (1=Yes; 0=No), which has been found to predict future quit attempts (Vangeli, Stapleton, Smit, Borland, & West, 2011) and conversations about health warning labels (Lambert et al., 2020; Thrasher et al., 2016).

Age (continuous), *sex assigned at birth* (female or male), and *race* (White, Black or African American, Latino/Latina/Latinx, Asian, Native Hawaiian or Pacific Islander,

American Indian or Alaska Native, or multiple races/ethnicities) were also assessed. Because recruitment and data collection methods varied across study sites and pre- and during-COVID-19 periods, all adjusted models controlled for *study site* (New York vs. South and North Carolina) and *study period* (data collected before vs. during the pandemic). *Experimental message condition* (i.e., text-only warning labels [reference], inserts with efficacy messages, pictorial warning labels, and efficacy inserts and pictorial labels) was also included in all adjusted models.

Data analysis

Aim 1 analyses. All analyses for this dissertation were conducted using Stata version 17. To assess the relationships between network attributes and conversations with alters (Figure 2.1), I used mixed effects (ME) logistic regression models, which account for repeated measures from participants. Separate models predicted the likelihood of conversations about the dangers of smoking and about the benefits of quitting on any given day. For each dependent variable, I estimated bivariate models and two sets of adjusted models. The first set of adjusted models included one primary independent variable (network characteristic) at a time, and all control variables. The second set of adjusted models included all control variables and network characteristics.

In assessing the extent and potential impact of missingness, I found 14% of the data for the dependent variables were missing and that network closeness, day in study, education, study period, age, and race were associated with having missing data for the dependent variables. Therefore, I used multiple imputation methods (Rubin, 1996) to investigate the effects of missingness on our analyses. I first developed an imputation

model that included all primary independent variables from our analysis models as well as control variables that were associated with missingness of the dependent variables. I then used chained equation methods to produce 20 imputations per outcome and re-estimated all relationships between the independent and dependent variables outlined in our hypotheses using the imputed data. The direction and significance of associations were the same between analyses using only observations with complete data and analyses using imputed data (See Appendix 2 in Manuscript 1); therefore, we report the results from complete cases analyses.

To assess the potential effects of COVID-19 as well as the change in data collection approach during that period (See Procedures section above), I also conducted a sensitivity analysis in which I stratified the results of my Aim 1 models before and during the COVID-19 outbreak. Results from these stratified models are included in the Appendix (Tables A1 and A2) and the end of this dissertation. These findings suggest that the relationships between network characteristics and conversations about smoking and cessation changed after the outbreak. Because of limited space in the manuscript for aim 1, I plan to write a subsequent paper on these findings that will allow for fuller discussion of the results stratified by pre and during COVID-19.

Aim 2 analyses. To assess the mediated relationships represented in the conceptual model for Aim 2 (Figure 2.2), I used generalized structural equation models to estimate direct, indirect, and total effects for each mediated relationship. In these models, conversations and mediating variables were regressed on all covariates to adjust for their potential influences on the relationships of interest. Instead of assessing conversations about smoking and cessation at the day-level as in Aim 1, I assessed these conversations

as the number of days participants reported conversations throughout the study period (0-14). The reason for this is that it is not possible to estimate generalized structural equation models with 2-2-1 models (i.e., independent variables and mediators at the participant level and dependent variables at the day level). Furthermore, I assessed income as a continuous variable for simplicity in mediation models and ease of interpreting results. As a sensitivity analysis, I also ran all models using a trichotomized income measure, as has often been done (Hitchman, Fong, Zanna, Thrasher, Chung-Hall, et al., 2014; Reid et al., 2010; Siahpush et al., 2009; Swayampakala, Thrasher, Hardin, et al., 2018), and found that neither the significance nor the direction of any results changed compared to using continuous income (See Appendix 1 in Manuscript 2).

For each indirect effect, I produced bootstrapped confidence intervals using the percentile bootstrap approach (Preacher & Hayes, 2008) and 1,000 resamples. I considered indirect effects to be significant if the confidence intervals of the indirect effects did not include zero. Conversations about the dangers of smoking and the benefits of quitting were assessed as separate dependent variables, and focal independent variables of income and education were assessed in different models. For each mediation model, I estimated results with and without the control variables. Using multiple imputation methods with GSEM models is not possible in Stata. Therefore, to control for potential effects of missing surveys on the outcomes, all models for this aim adjusted for the number of surveys participants provided (1-14).

Chapter 4

Associations of Egocentric Social Network Characteristics with Conversations about the Dangers of Smoking and Benefits of Quitting[5]

Abstract

Conversations sparked by cessation messages are associated with subsequent quit attempts, yet no research has investigated the characteristics of smokers' networks associated with these conversations. The aim of the current study was to assess associations between selected social network attributes and conversations about smoking and cessation in the context of exposure to novel cessation messages. Data came from a convenience sample of adult smokers in South Carolina, North Carolina, and New York state. At baseline, participants reported their egocentric network characteristics and received a 14-day supply of cigarettes with packs modified to include cessation messages on the inside and/or outside of their packs. Each night for 14 days, participants completed a survey that queried their conversations about smoking and cessation with network members in the prior 24 hours. We used bivariate and adjusted mixed effects logistic regression models to assess relationships between network attributes and conversations, with separate models predicting the likelihood of conversations about the dangers of smoking and about the benefits of quitting on any given day. In models adjusting for all

[5] Lambert, V.L., Thrasher, J.F., Leal, D.F., Davis, R.D., and Yang, C-H. To be submitted to *Journal of Health and Social Behavior.*

network and control variables, network disapproval of smoking (injunctive norms) and network smoking prevalence (descriptive norms) were positively associated with conversations about smoking harms and quitting benefits. Network size was negatively associated with, and average closeness to alters was positively associated with, conversations about quitting benefits. Our study suggests that social network characteristics – especially smoking norms – can influence conversations about smoking harms and cessation benefits. Future research should examine how, why, and by whom conversations about smoking and cessation are initiated and whether conversations with specific types of alters are associated with subsequent quitting.

Introduction

Social relationships affect mortality risk to a similar degree as other well-established behavioral predictors of mortality, such cigarette smoking, diet, and physical activity (Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015; Holt-Lunstad, Smith, & Layton, 2010). Relationships also influence health behaviors (Umberson, Crosnoe, & Reczek, 2010), including smoking cigarettes (Christakis & Fowler, 2008, 2012), with evidence suggesting that the structure and characteristics of social networks influence affect behaviors and health outcomes through various psychosocial mechanisms (Berkman & Krishna, 2015; Thoits, 2011; Umberson et al., 2010).

In research on smoking cessation, one network mechanism that has received some attention is interpersonal communication sparked by cessation messages. These conversations are associated with increased engagement with message content (Morgan et al., 2018) and subsequent quit attempts (Lambert, Davis, Popova, & Thrasher, 2020;

Morgan et al., 2018; Thrasher et al., 2016; van den Putte, Yzer, Southwell, de Bruijn, & Willemsen, 2011) and appear to be one of the pathways through which pictorial health warning labels (PHWLs) discourage smoking (Morgan et al., 2018). While one previous study used social network methods to examine the characteristics of people with whom smokers discuss PHWLs (Ramanadhan, Nagler, McCloud, Kohler, & Viswanath, 2017), no research has identified the network characteristics associated with conversations about smoking and cessation. To better understand how interventions can increase the occurrence these conversations, it is critical to identify the social network conditions that encourage them (Valente, 2011). In the current paper, we investigate associations between selected social network attributes and conversations about the harms of smoking and the benefits of quitting (hereafter referred to as "conversations about smoking and cessation") in the context of exposure to novel cessation messages on and/or in cigarette packs, as there is evidence that exposure to novel pictorial and text-only messages on cigarette packs encourages conversations about the harms of smoking and the benefits of quitting (Brewer et al., 2016).

Social Network Characteristics and Conversation about Smoking and Cessation

Network Size

People with larger social networks tend to receive more support for personal concerns (Martí, Bolíbar, & Lozares, 2017) and be more likely to seek health information from family and friends (Askelson, Campo, & Carter, 2011; Song & Chang, 2012).[6]

[6] The studies demonstrating these associations are not directly comparable with the data used in this study as they used non-truncated network name generators or allowed for a much greater number of alters compared to the current study. In contrast, the data for this study comes from a truncated name generator that limited participants' network size to 5 alters (see methods for justification for this decision). No studies

Thus, smokers with larger networks may also be more likely to receive support for smoking cessation and to seek advice for cessation from their networks, which may be operationalized as conversations about smoking and cessation.

Tie Strength: Frequency of Communication and Perceived Closeness

Tie strength – including frequency of contact with and perceived closeness of network alters (i.e., people in one's network)– may also influence conversations about smoking and cessation. Smokers should have more opportunities for these conversations when they talk frequently with their alters. Likewise, closer alters may encourage these conversations, as alters who are closer emotionally are more likely to provide support for personal matters and health (Martí et al., 2017). However, people sometimes avoid conversations about important topics with close alters (Small, 2017), perhaps out of embarrassment or fear of judgement and rejection from those alters. Because close alters are important, initiating difficult conversations may seem more risky (Small, 2017), which could lead smokers to avoid conversations about their smoking and cessation with stronger alters.

Network Injunctive Smoking Norms: Disapproval of Smoking

Smoking norms within smokers' networks also likely affect conversations about smoking and cessation, though it is unclear if this relationship would be negative or positive. Injunctive norms (i.e., perceptions of others' approval or disapproval of smoking or cessation) have been associated with quit attempts (Rennen et al., 2014),

to our knowledge have assessed associations between network size and support, health information, or interpersonal discussions using a truncated name generator.

smoking abstinence (Hammond, Fong, Zanna, Thrasher, & Borland, 2006), quit intentions (Brown, Moodie, & Hastings, 2009; Hammond et al., 2006; Hosking et al., 2009) and other behaviors predictive of quitting (Schoenaker, Brennan, Wakefield, & Durkin, 2018). Because conversations about smoking and cessation also predict cessation outcomes, more widespread smoking disapproval among network alters could encourage these conversations.

The only study to investigate the relationship between injunctive smoking norms and conversations about quitting found that perceived disapproval of smoking was not associated with conversations about quitting (Schoenaker et al., 2018). However, that study used a single measure to assess perceived disapproval of smoking and a single measure to assess conversations about quitting with all family or friends (Schoenaker et al., 2018). By combining all family and friends, those measures may have imprecisely assessed these constructs since people may not be accurate at summarizing the disapproval and recalling conversations across several people or types of alters. Further, because the measures in the previous study did not assess closeness or frequency of contact with alters, they also may not have captured people who are most likely to influence smoking behavior or who interact with smokers regularly enough to have conversations about smoking and cessation. The previous study also asked people to recall conversations they had in the past week (Schoenaker et al., 2018), which introduces possible recall bias. Hence, a more nuanced, longitudinal investigation of the relationships between network smoking disapproval and conversations about smoking and cessation is warranted.

Sociological research suggests that injunctive norms could be negatively associated with conversations about smoking and cessation. People often actively avoid discussing important topics with close alters when they expect the alter will not provide the type of support they are seeking, which may lead to a difficult interaction (Small, 2013, 2017). Hence, to prevent judgement, nagging, or otherwise challenging interactions, smokers with close alters who disapprove of their smoking may avoid talking with them about smoking and cessation.

Network Descriptive Smoking Norms: Smoking Prevalence

Network descriptive smoking norms (i.e., the prevalence of smoking in one's network) may also influence conversations about smoking and cessation. Smokers who have more smokers in their networks have more difficulty quitting (Blok, de Vlas, van Empelen, & van Lenthe, 2017; Hitchman, Fong, Zanna, Thrasher, & Laux, 2014; Thomas et al., 2019). Therefore, the number of smokers in one's network may be negatively associated with conversations about smoking and cessation. However, it is also possible that a higher prevalence of smokers in one's social network increases conversations about smoking and cessation, as PHWL studies have found that smokers talk more often about PHWLs with fellow smokers than with non-smokers (Hall et al., 2015; Morgan et al., 2017). People often smoke around other smokers (Shapiro, Jamner, Davydov, & James, 2002), and being around others who are smoking may trigger smokers to light up (Shiffman et al., 2002). As such, smoking sessions with other smokers may provide opportunities for social exposure to and discussion of cessation messages on cigarette packs, including more general discussions of smoking and cessation.

Relatedly, having former smokers in one's network may encourage conversations about smoking and cessation. Being socially connected to former smokers appears to promote cessation (Aschbrenner et al., 2018; Burgess-Hull, Roberts, Piper, & Baker, 2018; Christakis & Fowler, 2008; Schoenaker et al., 2018; van den Putte, Yzer, & Brunsting, 2005), and some evidence suggests that people discuss important matters with network members they consider to have expertise on the topic being discussed (Small, 2013). Moreover, because research suggests that social support and advice from network members is often unsolicited (Deelstra et al., 2003; Thoits, 2011; Umberson et al., 2010), especially among close alters (Feng & Magen, 2016), network members who used to smoke may offer advice on cessation, even when smokers do not seek it.

Having a significant other

Trials of PHWLs have found many smokers (34% - 42%) talk to spouses about the warnings (Hall et al., 2015; Morgan et al., 2017). Spouses and significant others often live in the same home, communicate frequently, and are often emotionally closer than other network members. Hence, smokers with a spouse or significant other will have a person they likely see very frequently and talk to about personal matters, including their health, which may encourage conversations about smoking and cessation. Thus, having a spouse or significant other should be associated with more conversations about smoking and cessation.

Study aim, key definitions, and hypotheses

The aim of the current study is to investigate associations between the network characteristics described above and conversations about smoking harms and quitting

benefits in the context of exposure to novel cessation messages. Our data came from an intensive longitudinal study in which smokers in the U.S. reported the conversations in their personal (egocentric) network about smoking and cessation each day over the course of 14 consecutive days. An egocentric network is centered around a single person, or study participant (referred to in network literature as an ego), and network alters are the people within each person's network (Perry, Pescosolido, & Borgatti, 2018). The current study will be the first to use daily assessments to investigate conversations about smoking and cessation and to use both egocentric social network methods and daily assessments to assess interpersonal communication. Based on the literature described above, we developed several hypotheses about the relationships between network characteristics and conversations about smoking and cessation:

Hypotheses

H1. Network size will be positively associated with the likelihood of having conversations about smoking and cessation with alters.

H2. Compared to participants with no former smokers in their network, participants with at least one former smoker in their network will be more likely to have conversations about smoking and cessation with alters.

H3. Compared to participants who did not report a spouse or significant other in their network, participants with a spouse or significant other in their network will be more likely to have conversations about smoking and cessation with alters.

Exploratory hypotheses

H4. Tie strength (average perceived closeness and baseline frequency of communication) will be associated with the likelihood of having conversations about smoking and cessation with alters.

H5. The number of alters that disapprove of smoking will be associated with the likelihood of having conversations about smoking and cessation with alters.

H6. The number of network smokers will be associated with the likelihood of having conversations about smoking and cessation with alters.

Methods

Sample and recruitment

This observational study used data from a between-subjects randomized controlled trial that was conducted between 2019-2021 with adult smokers in the United States, where cigarette packs featured small text-only health warning labels that have been on cigarette packs since 1984. Based on self-reported cigarettes per day, participants were given a 14-day supply of their preferred cigarette brand with packs modified to reflect four experimental conditions, all of which were novel relative to current messages on U.S. packs. The message conditions included text-only warning labels; text-only warning labels and inserts (i.e., small, printed leaflets placed inside packs) with efficacy messages; pictorial warning labels with the same textual content as the text-only warnings; and inserts with efficacy messages and pictorial warning labels (see Appendix

1).[7] Data collection began on June 28th, 2019, and continued until July 6th, 2021, spanning periods before and during the COVID-19 pandemic.

Participants were recruited from South Carolina, North Carolina, and New York state. Adult smokers (i.e., ≥18 years old) were eligible if they spoke and read English, reported smoking at least 100 cigarettes in their lifetime and at least 10 cigarettes each day in the prior month. Smokers who used other nicotine products in the prior month were ineligible due to challenges assessing compensatory behaviors involving other nicotine products when reducing cigarettes. Beginning in January 2020, the minimum age to participate was increased to 21 due to the implementation of a federal policy that raised the legal age to purchase tobacco to 21.

Multiple recruitment methods were used. In New York state during the pre-COVID-19 period, a mobile van recruited participants outside smoke shops in low-income neighborhoods throughout different cities across central New York. In New York state during the Covid period, South Carolina, and North Carolina, social media advertisements were used to recruit participants. Screening for eligibility was done in person or online depending on recruitment modality. After eligibility was assessed, all

[7] The current study does not focus on messaging effects for several reasons: 1) Across all conditions, participants were exposed to novel messages on or in cigarette packs that likely all sparked some conversations about smoking harms and cessation, even the control group (Brewer et al., 2016). 2) The current analysis aims to isolate the social network conditions that encourage conversations about smoking harms and cessation, separate from messaging effects. 3) The current study was likely not adequately powered to assess the effects of the four message conditions on conversations about smoking and cessation, which is an infrequent behavior (Brewer et al., 2016). Power for this study was lower than expected due to high interclass correlation coefficients despite relatively strong effect sizes; hence, the sample size is not adequate for detecting what may be relatively small effects. 4) Because our measures of conversations were not limited to conversations sparked by or about the messages, we captured conversations that were not necessarily a direct result of message exposure.

participants provided informed consent, which was done in person with a physical consent document and signature before COVID-19 and through an online form and signature during COVID-19. Full details about the sample and recruitment are described elsewhere (Thrasher et al., n.d.).

Procedures

The University of South Carolina's institutional review board approved the study procedures before data collection began. At baseline, participants completed two assessments. They first took a self-administered survey that assessed smoking-related attitudes and behaviors and socio-demographics. They then completed an interviewer-administered survey to assess their social network characteristics. The method of data collection for the social network variables changed from in-person interviews during the pre-COVID-19 period (i.e., June 28, 2019 to March 5, 2020) to telephone interviews after the COVID-19 outbreak (i.e., August 13, 2020 to June 30, 2021). Evidence suggests that face-to-face and telephone interviews are similarly reliable for assessing egocentric network characteristics, especially for questions about alter behaviors (e.g., alter smoking) (Kogovšek & Ferligoj, 2005). However, face-to-face interviews appear to produce less valid results overall than telephone interviews (Kogovšek & Ferligoj, 2005). Furthermore, network size appears to vary by data collection mode, with larger networks generated during telephone interviews than face-to-face interviews (Kogovšek, Ferligoj, Coenders, & Saris, 2002). Immediately after the baseline assessments, participants began a 14-day period during which they completed one survey each night to assess conversations about smoking harms and cessation benefits. Full details about the study protocol have been published elsewhere (Thrasher et al., n.d.).

Measures

Independent variables (assessed at baseline)

Network generator. To elicit alters, we used a name generator that asked, "Of the people with whom you are closest, who have you spent the most time with in the past two weeks?" Participants could name up to 5 people, as some evidence suggests 5 alters is the ideal number to maximize non-redundant network information while minimizing participant burden in network name generators (Merluzzi & Burt, 2013). Furthermore, because it is unlikely that young children would have discussions about smoking and cessation, participants were not allowed to name children younger than 3 years old.

The purpose of our network name generator was to elicit alters with whom participants felt close and were likely to interact over the two-week study period. Thus, it was both affect-based and interaction-based, which are two popular types of name generators in egocentric network studies (Perry et al., 2018). One advantage of having an affect component is that emotionally closer alters are those most likely to influence participants' attitudes and behaviors ((Burt, 1984) as cited in (Perry et al., 2018)). Moreover, alters generated by self-reports of interaction are highly reliable over time and are most often long-term alters who are both frequently and recently contacted by participants (Marsden, 1990). Other studies have taken a similar approach of combining affect and interaction name generators into a single name generator (cf. (Kitts & Leal, 2021)).

Network attributes. To measure alter characteristics, we used an alter-wise ordering approach in which all characteristics of each named alter were assessed before asking questions about the characteristics of other alters.

Network size represents the number of alters each participant named in the name generator, with values ranging from 0-5.

Tie strength for each alter was measured with two items. The first item assessed *perceived closeness* and asked participants how close they felt to each alter, with response options ranging from "Not at all close" (1) to "Extremely close" (5). We adapted this item from a Gallup Panel survey that is not publicly available but has been used in published research (e.g., (Pachucki & Leal, 2020; Shakya & Christakis, 2017)). The second indicator of tie strength was *frequency of communication*, which was assessed by asking participants how often they talked to each alter. Response options included "Every day" (1), "Several times a week" (2), "Once a week" (3), "Once every two weeks" (4), "Once a month or less" (5), and "Don't know." We adapted this item from the National Social Life, Health and Aging Project (NSHAP) (Waite et al., 2017). "Don't know" responses were recoded to missing. Then, we reverse coded the responses so that higher values represented more frequent interactions. For each network, we generated an average for perceived closeness and for frequency of interactions, and we assessed these two indicators of tie strength as separate variables in all analyses.

Having a spouse or significant other in one's network was derived from an item adapted from the NSHAP (Waite et al., 2017) that asked participants the type of relationship they had with each alter. Response options included, "Spouse", "Partner or

significant other", "Parent", "Child", "Other family", "Friend", "Work colleague", "Neighbor, "Acquaintance", and "Other." Participants could only select one option for each alter. For each network, we created a binary variable to indicate whether each participant named a spouse or significant other (0=Did not name spouse or significant other; and 1=Named spouse or significant other).

The smoking status of each alter was assessed by asking "To the best of your knowledge, does [name of alter] smoke cigarettes?" Response options included "No", "Not now, but used to smoke", "Yes", and "Don't know." For each network, we created a variable that counted the *number of smokers*, that is, the number of alters for which the participant responded "Yes" to the smoking status question (range 0 smokers – 5 smokers). We also created a binary variable to indicate whether each *network had a former smoker*, that is, the participant indicated "Not now, but used to smoke" about 1 or more alters (0= No former smokers; 1=1 or more former smokers).

Smoking approval was assessed for each alter by asking participants, "What does [name of alter] think about your smoking?". Response options ranged from "Strongly disapproves" (1) to "Strongly approves" (5). We developed this item based on the theories of normative conduct (Cialdini, Reno, & Kallgren, 1990) and normative influence (Rimal & Real, 2005) as well as measures of smoking disapproval (injunctive norms) used in prior research (Hammond et al., 2006; Schoenaker et al., 2018; van den Putte et al., 2005). We dichotomized this variable for each alter to indicate disapproval of smoking, with 1= Strongly disapproves or Disapproves and 0 = Neutral, Approves, or Strongly approves. We then created a count for each network of the *number of alters disapproving of smoking* (0 disapprove – 5 disapprove).

Dependent variables (assessed in daily surveys)

Conversations about the dangers of smoking and *conversations about the benefits of quitting* with alters were assessed in three steps in the daily surveys. First, the survey asked, "In the last 24 hours, have you talked with [list of alters named at baseline] about good or bad things about smoking or quitting?" (0=No, 1=Yes). Second, if a participant selected "Yes", the survey repeated the same question for each alter (e.g., "In the last 24 hours, have you talked with [alter 1] about good or bad things about smoking or quitting?" (0=No, 1=Yes)).[8] Third, for each alter that a participant reported talking with about smoking or quitting, the participant was asked to report what they talked about with that alter. Response options included "How much you like smoking", "Dangers of smoking to you", "Benefits of quitting smoking", "Cigarette pack health messages are informative", "Cigarette pack health messages are NOT believable", "Cigarette pack health messages are useless", and "Other topics." Studies have found that conversations about quitting smoking (Jeong, Tan, Brennan, Gibson, & Hornik, 2015; van den Putte et al., 2011) and conversations that characterize smoking negatively (Ramanadhan et al., 2017) are more strongly associated with cessation outcomes compared to other conversations sparked by cessation messages. Therefore, our analyses only included conversations in which the topics "Dangers of smoking to you" or "Benefits of quitting smoking" were discussed. These two topics were treated as separate dependent variables and coded dichotomously (0=Did not discuss topic on that day; 1=Discussed topic on that day).

[8] To reduce potential bias from prompting participants to think about the cigarette labeling messages by constantly asking them about the messages in the nightly surveys, the measures did not explicitly ask about conversations about the cigarette package labels.

Control variables (assessed at baseline)

Cigarettes per day was assessed with an item that asked, "On average, how many cigarettes do you smoke each day, including both factory-made and roll-your-own cigarettes?"

Recent quit attempt was measured by asking smokers if they had attempted to quit smoking in the past year. Recent quit attempts may predict both future quit attempts and conversations about health warning labels (Lambert et al., 2020; Thrasher et al., 2016).

Intention to quit smoking was also assessed, and responses were dichotomized to indicate intention to quit within the next six months (1=Yes; 0=No), which has been found to predict future quit attempts (Vangeli, Stapleton, Smit, Borland, & West, 2011) and conversations about health warning labels (Lambert et al., 2020; Thrasher et al., 2016).

Income level (<$30,000; $30,000-$59,000; or ≥$60,000), *education level* (≤ high school; technical school, community college, or some college; or university degree or more), *age* (continuous), *sex assigned at birth* (female or male), and *race* (White, Black or African American, Latino/Latina/Latinx, Asian, Native Hawaiian or Pacific Islander, American Indian or Alaska Native, or multiple races/ethnicities) were also assessed. Because recruitment and data collection methods varied across study sites and pre- and during-COVID-19 periods, all adjusted models controlled for *study site* (New York vs. South and North Carolina) and *study period* (data collected before vs. during the pandemic). *Experimental message condition* (i.e., text-only warning labels [reference],

inserts with efficacy messages, pictorial warning labels, and efficacy inserts and pictorial labels) and *day in study* (day 1- day 14) were also included in all adjusted models.

Analysis

We used Stata version 17 for all analyses. For each network variable described above, we created a network-level average or score for each participant. To assess the relationships between network attributes and conversations with alters, we used mixed effects (ME) logistic regression models, which account for repeated measures from participants. Separate models predicted the likelihood of conversations about the dangers of smoking and about the benefits of quitting on any given day. For each dependent variable, we estimated bivariate models and two sets of adjusted models. The first set of adjusted models included one primary independent variable (network characteristic) at a time, and all control variables. The second set of adjusted models included all control variables and network characteristics.

For each model, a logistic regression model defining two levels was estimated as follows: *i* for a given EMA (nightly survey); and *j* for a given participant. The general specification for the models was:

$$\boldsymbol{Y_{ij}=\beta_{0j}+\beta_1 X_{1j}\ldots+\beta_k X_{kj}+e_{ij}+u_{j0}}$$

Y_{ij} is the odds of reporting a conversation about smoking or about cessation in the nightly survey i submitted by participant j. β_{0j} is the intercept. e_{ij} represents the level 1 (observation) error while u_{j0} represents the level 2 (participant) error. $\beta_1 - \beta_k$ are the fixed effects and X_{1j} - X_{kj} are the time-invariant (level 2) covariates (i.e., social network characteristics and control variables).

In assessing the extent and potential impact of missingness, we found 14% of the data for the dependent variables were missing and that network closeness, day in study, education, study period, age, and race were associated with having missing data for the dependent variables. Therefore, we used multiple imputation methods (Rubin, 1996) to investigate the effects of missingness on our analyses. We first developed an imputation model that included all primary independent variables from our analysis models as well as control variables that were associated with missingness of the dependent variables. We then used chained equation methods to produce 20 imputations per outcome and re-estimated all relationships between the independent and dependent variables outlined in our hypotheses using the imputed data. The direction and significance of associations were the same between analyses using only observations with complete data and analyses using imputed data; therefore, we report the results from complete cases analyses (See Appendix 2).

Results

Sample characteristics. Descriptive statistics of study variables are in Table 4.1. The analytic sample (n=366) was mostly female (60%), white (81%), and had greater than a high school education (58%). At baseline, most of the sample neither intended to quit smoking in the next six months (67%) nor had tried to quit in the prior 12 months (69%). The average cigarettes smoked per day was 21.6 (SD=9.20). On average, participants reported talking with alters about the dangers of smoking on one day during the 14-day data collection period (Mean=1.12, SD=2.05) and about the benefits of quitting slightly more often (Mean=1.39, SD=2.18).

Table 4.1 Key variable descriptive statistics. (n=366)

	Mean (SD) or %
Dependent variables	
Conversations with alters	
About dangers of smoking	1.12 (2.05)
About benefits of quitting	1.39 (2.18)
Independent variables (network characteristics)	
Network size (1-5)	3.20 (1.33)
1 alter	13.11%
2 alters	18.31%
3 alters	26.23%
4 alters	19.67%
5 alters	22.68%
Has spouse or significant other	56.56%
Perceived closeness (1 Not at all close - 5 Extremely close)	4.29 (0.62)
Frequency of communication (1 Once a month or less - 5 Every day)	4.64 (0.44)
Number of current smokers (0-5)	1.48 (1.13)
Has one or more former smokers	23.20%
Number of alters disapproving of smoking (0-5)	1.46 (1.22)
Control variables	
Age	44.2 (12.2)
Sex at birth	
Female	60.38%
Male	38.52%
.	1.09%
Race	
White	80.33%
Black or African American	12.84%
Latino/Latina/Latinx	2.73%
Asian	0.55%
Native Hawaiian or Pacific Islander	0.27%
American Indian or Alaska Native	1.09%
Multiple races/ethnicities	1.09%
.	1.09%
Cigarettes per day	21.6 (9.20)
Recent quit attempt (past year)	
Yes	28.96%
No	69.40%
Missing (includes DK)	1.64%
Intention to quit within 6 months	
Yes	32.24%
No or don’t know	66.94%
.	0.82%
Location	

NY	54.92%
SC/NC	45.08%
Study period	
Pre-COVID	55.46%
During COVID	44.54%
Experimental message condition	
Control	27.60%
Inserts	23.77%
GHWLs	24.59%
Inserts + GHWLs	24.04%
Education level	
≤ High school	41.80%
Technical school, community college, or some college	40.71%
University degree or more	16.12%
.	1.37%
Income level	
<$30,000	42.35%
$30,000-$59,000	33.61%
≥$60,000	20.22%
.	3.83%

Correlates of conversations with alters about harms of smoking and benefits of quitting

Table 4.2 shows the bivariate and adjusted associations between network characteristics and conversations with alters about the harms of smoking. The number of alters disapproving of smoking was positively associated with conversations about the harms of smoking in all three models (OR= 1.29, $p<0.05$; AOR=1.33 $p<0.05$; AOR=1.56, $p<0.01$, respectively). The number of network smokers was positively associated with these conversations in the model that adjusted for all network and control variables (AOR=1.49, $p<0.05$). Table 4.3 shows the bivariate and adjusted associations between network characteristics and conversations with alters about the benefits of quitting. Network closeness was positively associated with conversations about the benefits of quitting in all 3 models (OR=1.52, $p<0.05$; AOR=1.65, $p<0.05$; AOR=1.64, $p<0.05$ respectively). In the model that adjusted for all network and control variables, network

size was negatively associated with conversations about quitting benefits (AOR=0.71, $p<0.05$), and the number of network smokers (AOR=1.62, $p<0.01$) and number of alters disapproving of smoking (AOR=1.43, $p<0.05$) were positively associated with these conversations.

Table 4.2 Associations between network characteristics and conversations with alters about the harms of smoking.

	Bivariate models OR (95% CI) n=365-366		One IV + controls[1] AOR (95% CI) n=348-349		Full model (All IVs + controls)[2] AOR (95% CI) n=348	
Network size	1.08	(0.89, 1.32)	1.19	(0.96, 1.47)	0.85	(0.60, 1.20)
Has spouse/significant other	1.08	(0.64, 1.80)	1.30	(0.73, 2.32)	1.04	(0.57, 1.91)
Closeness	1.42	(0.92, 2.21)	1.50	(0.93, 2.39)	1.47	(0.86, 2.52)
Frequency of communication	1.15	(0.63, 2.11)	1.09	(0.58, 2.05)	1.10	(0.54, 2.22)
Number of network smokers	1.08	(0.86, 1.36)	1.14	(0.90, 1.44)	**1.49***	(1.06, 2.08)
Has one or more former smoker	1.09	(0.59, 2.03)	1.26	(0.65, 2.43)	1.27	(0.64, 2.54)
Number of alters disapproving of smoking	**1.29***	(1.05, 1.60)	**1.33***	(1.07, 1.66)	**1.56****	(1.12, 2.17)

*p<.05, **p<.01

Notes: Mixed effects logistic regression models were used for all analyses.
OR= odds ratio and AOR= adjusted odds ratio. Adjusted models controlled for day in study, income, education, cigarettes per day, quit attempt in past 12 months, intention to quit within next 6 months, location, pre vs. during COVID, experimental message condition, age, sex at birth, and race.

[1]Each row represents results from a separate adjusted model (network characteristic indicated in the row and all control variables)

[2]Results in this column are from a single model that adjusted for all network characteristics and control variables.

Table 4.3 Associations between network characteristics and conversations with alters about the benefits of quitting.

	Bivariate models OR (95% CI) n=365-366		One IV + controls[1] AOR (95% CI) n=348-349		Full model (All IVs + controls) [2] AOR (95% CI) n=348	
Network size	0.98	(0.83, 1.16)	1.01	(0.84, 1.22)	**0.71***	(0.53, 0.97)
Has spouse/significant other	1.17	(0.74, 1.86)	1.38	(0.83, 2.28)	1.21	(0.71, 2.06)
Closeness	**1.52***	(1.04, 2.23)	**1.65***	(1.10, 2.47)	**1.64***	(1.03, 2.60)
Frequency of communication	1.06	(0.63, 1.80)	1.09	(0.63, 1.88)	0.90	(0.49, 1.64)
Number of network smokers	1.11	(0.90, 1.36)	1.15	(0.94, 1.42)	**1.62****	(1.20, 2.19)
Has one or more former smoker	1.30	(0.76, 2.23)	1.45	(0.82, 2.55)	1.78	(0.98, 3.23)
Number of alters disapproving of smoking	1.15	(0.95, 1.38)	1.13	(0.94, 1.37)	**1.43***	(1.06, 1.91)

*p<.05, **p<.01

Notes: Mixed effects logistic regression models were used for all analyses.
OR= odds ratio and AOR= adjusted odds ratio. Adjusted models controlled for day in study, income, education, cigarettes per day, quit attempt in past 12 months, intention to quit within next 6 months, location, pre vs. during COVID, experimental message condition, age, sex at birth, and race.

[1]Each row represents results from a separate adjusted model (network characteristic indicated in the row and all control variables)

[2]Results in this column are from a single model that adjusted for all network characteristics and control variables.

Discussion

In our analysis of associations between ego network characteristics and conversations with alters about smoking harms and cessation benefits, we found more network characteristics were associated with conversations about the benefits of quitting than about the harms of smoking. While our study assessed networks of close alters, some evidence suggests people often confide in non-close alters about important topics,

and at times to avoid difficult interactions (Small, 2017). Therefore, it could be that smokers discuss more negative topics – such as the dangers of smoking – outside of their networks of close alters.

The number of alters disapproving of smoking was positively associated with conversations about both the harms of smoking and the benefits of quitting, which suggests injunctive norms are key to encouraging conversations about smoking and cessation that may lead to quitting. Because these conversations are an important outcome for cessation communication interventions, those developing these interventions may consider approaches that target smokers' social network alters who are disapproving of smoking to encourage dialogue about smoking and cessation. More broadly, our findings join a sizable body of research documenting the influence of injunctive smoking norms on cessation outcomes (Brown et al., 2009; Hammond et al., 2006; Hosking et al., 2009; Rennen et al., 2014; Schoenaker et al., 2018; van den Putte et al., 2005), which are most effectively changed through policy interventions that have impacts at the population level (Cummings, Fong, & Borland, 2009; Durkin, Schoenaker, Brennan, Bayly, & Wakefield, 2021; Fong, Chung-Hall, Craig, & WHO FCTC Impact Assessment Expert Group, 2018; Fong et al., 2006; Hammond et al., 2006; Rennen et al., 2014). Policies can influence norms directly – such as through media and advertisements – or indirectly – such as through regulations and taxes that signal what is right and wrong or discourage a behavior so that it becomes societally unacceptable (Kinzig et al., 2013).

The number of network smokers was also positively associated with conversations about smoking harms and quitting benefits, which corresponds with a prior study that found smokers talk more often about PHWLs with smokers than with non-

smokers (Hall et al., 2015; Morgan et al., 2017). Though other research suggests that social connections with smokers makes it more difficult to quit smoking (Blok et al., 2017; Hitchman et al., 2014; Thomas et al., 2019), it appears these connections also encourage conversations that may promote cessation. More research is needed to understand if discussing smoking harms and quitting benefits with other smokers actually leads to quitting; however, communication and social network interventions may consider prompting smokers to discuss smoking and cessation with other smokers.

Average closeness was positively associated with conversations about the benefits of quitting in a bivariate model and adjusted models. However, average closeness was not significantly associated with conversations about the harms of smoking, which suggests close alters are more likely to encourage supportive conversations rather than critical conversations or that smokers avoid negative conversations about their smoking with closer alters, which is consistent with research on network mobilization (Small, 2017). To better understand whether smokers avoid discussing the harms of smoking with close alters, more research is needed that investigates who initiates these conversations. Contrary to what we expected, our other measure of network strength – frequency of communication – was not associated with conversations about smoking harms or quitting benefits. Because the network generator we used elicited names of alters with whom participants had spoken in the prior 2 weeks, there may not have been enough variability in the frequency of communication to detect a relationship with conversations. Indeed, as shown in Table 4.1, there was less variability in the frequency of communication with networks compared to our measure of average closeness (see Table 4.1). While future research should examine these relationships within networks including both weaker and

stronger ties, our results suggest perceived closeness is more important than frequency of communication for encouraging conversations that potentially promote cessation.

Our finding that network size was negatively associated with conversations about quitting benefits was contrary to our hypothesis that larger networks would predict more conversations. Moreover, this finding is inconsistent with prior research that has found smokers with larger networks report more social support for quitting (Martí et al., 2017) and are more likely to seek information from friends and family for quitting (Askelson et al., 2011; Song & Chang, 2012). One reason for the discrepancy between our expectations and results around network size could be that prior studies demonstrating a positive association between smokers' network size and provision and seeking of support used either non-truncated network generators (i.e., no limit to network size) or had a much larger limit on network size compared to our study. By restricting network size in the current study to five close and frequently contacted alters, we limited the range of network size and did not capture weaker ties, who may be important discussants in conversations about smoking and cessation.

Most network characteristics we expected to be associated with conversations about smoking harms and quitting benefits were not associated with either topic of conversation. This could be because our study was inadequately powered to identify the associations of some network characteristics with these conversations, which may have a small effect size. For example, having a former smoker in one's network was not associated with conversations in our study. While other studies have found social relationships with former smokers appear to promote cessation outcomes (Burgess-Hull et al., 2018; Christakis & Fowler, 2008; Schoenaker et al., 2018; van den Putte et al.,

2005), these studies had much large sample sizes (i.e., n=1,571 - 12,067) than our study. Moreover, other studies that have analyzed conversations about smoking and cessation as dependent variables collected data for longer periods of time (e.g., Brewer et al., 2016 assessed conversations for 1 month), so our study had less opportunity to capture these conversations compared to those prior studies. Future research with larger samples and/or longer study periods may be needed to better assess the relationships between some network attributes and conversations about smoking and cessation.

Another limitation of our study was that we did not assess connections between alters, which is a key measure for understanding social influence on behaviors. For example, if a participant's alters who disapproved of smoking were all connected with one another, this may have led to more pressure to quit (i.e., more conversations about quitting) than if these alters did not know one another. Future research should investigate this possibility.

Our convenience sample was not representative of U.S. smokers and, hence, also has limited generalizability. Relative to the general population, our sample had higher income and education levels and included relatively few non-white or Latino/a/x smokers. While it is unclear what effect these attributes might have had on the relationships we assessed, there is evidence that social network characteristics vary by race, ethnicity, and SES (Albert & Hajdu, 2020; Alwin, Thomas, & Sherman-Wilkins, 2018; Brashears, 2011; Schafer & Vargas, 2016). Future research should be conducted among more representative samples that are powered to assess the potential moderation effects of race and other effects of socio-demographic characteristics. Because non-white smokers - especially Black smokers - and lower-SES smokers are disproportionately

impacted by smoking-related diseases (Glei, Lee, & Weinstein, 2020; Lawrence et al., 2022), it is crucial to expand this area of research to better represent those groups.

In conclusion, our study provides evidence that smokers' network injunctive and descriptive norms influence conversations about smoking and cessation. Other network characteristics may also encourage these conversations, but the evidence for these associations was more limited in our study. Future research should examine how, why, and by whom conversations about smoking and cessation are initiated and whether conversations with specific types of alters are associated with subsequent quitting.

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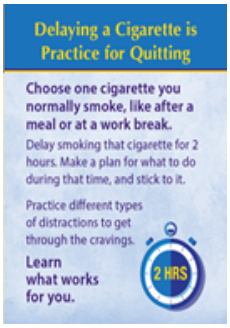
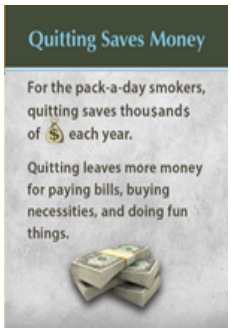
Appendix 1. Study messages

Table 4.4 Messages on and in packs

Inserts	Pictorial health warning labels	Example pack
 *Self-efficacy (quit tips)*		
 *Self-efficacy (quit tips)*		

Response efficacy (quit benefits)



Response efficacy (quit benefits)

Appendix 2. Results using imputed data

Table 4.5 Associations between network characteristics and imputed conversations with alters about the harms of smoking.

	Analysis of imputed data					
	Bivariate results OR (95% CI) n=365-366		One IV + controls AOR (95% CI)[1] n=348-349		Full model (All IVs + controls) AOR (95% CI)[2] n=348	
Network size	1.08	(0. 91, 1.29)	1.16	(0.96, 1.40)	0.88	(0.66, 1.18)
Has spouse/significant other	1.07	(0.69, 1.67)	1.21	(0.75, 1.97)	1.00	(0.61, 1.66)
Closeness	1.30	(0.90, 1.89)	1.38	(0.92, 2.05)	1.38	(0.89, 2.15)
Frequency of communication	1.11	(0.67, 1.87)	1.08	(0.64, 1.84)	1.14	(0.64, 2.02)
Number of network smokers	1.10	(0.90, 1.33)	1.14	(0.94, 1.39)	**1.43***	(1.08, 1.90)

Has one or more former smoker	1.08	(0.64, 1.79)	1.20	(0.70, 2.05)	1.22	(0.70, 2.13)
Number of alters disapproving of smoking	**1.24***	(1.04, 1.48)	**1.26***	(1.04, 1.51)	**1.44***	(1.09, 1.91)

*p<.05, **p<.01

Notes: Mixed effects logistic regression was used to assess relationships between network characteristics and conversations.

OR= odds ratio and AOR= adjusted odds ratio. Adjusted models controlled for day in study, income, education, cigarettes per day, quit attempt in past 12 months, intention to quit within next 6 months, location, pre/post COVID, experimental condition, age, sex at birth, and race.

[1]Each row represents results from a separate adjusted model (network characteristics indicated in the row and all control variables)

[2]Results in this column are from a single model that adjusted for all network characteristics and control variables.

Table 4.6 Associations between network characteristics and imputed conversations with alters about the benefits of quitting.

Analysis of imputed data						
	Bivariate results OR (95% CI) n=365-366		One IV + controls AOR (95% CI)[1] n=348-349		Full model (All IVs + controls) AOR (95% CI)[2] n=348	
Network size	0.98	(0.85, 1.14)	1.01	(0.86, 1.18)	**0.75***	(0.57, 0.98)
Has spouse/significant other	1.15	(0.77, 1.72)	1.30	(0.83, 2.02)	1.16	(0.73, 1.84
Closeness	**1.40***	(1.01, 1.94)	**1.52***	(1.08, 2.16)	**1.51***	(1.02, 2.24)
Frequency of communication	1.08	(0.69, 1.70)	1.10	(0.69, 1.75)	0.97	(0.58, 1.61)
Number of network smokers	1.10	(0.93, 1.31)	1.15	(0.95, 1.36)	**1.53****	(1.17, 1.99)
Has one or more former smoker	1.23	(0.78, 1.94)	1.34	(0.82, 2.17)	1.61	(0.97, 2.66)
Number of alters disapproving of smoking	1.11	(0.95, 1.31)	1.10	(0.93, 1.30)	**1.35***	(1.04, 1.75)

*p<.05, **p<.01

Notes: Mixed effects logistic regression was used to assess relationships between network characteristics and conversations.

OR= odds ratio and AOR= adjusted odds ratio. Adjusted models controlled for day in study, income, education, cigarettes per day, quit attempt in past 12 months, intention to quit within next 6 months, location, pre/post COVID, experimental condition, age, sex at birth, and race.

[1]Each row represents results from a separate adjusted model (network characteristics indicated in the row and all control variables)

[2]Results in this column are from a single model that adjusted for all network characteristics and control variables.

Chapter 5

Smokers' Socioeconomic Status and Network Characteristics and Their Association with Conversations about Smoking Harms and Cessation Benefits[9]

Abstract

Conversations about smoking harms and cessation in response to cessation messages appear to encourage quit attempts, yet there is some evidence that smokers with lower income and education have these conversations less often than smokers with higher income and education. While no research has assessed the mechanisms for socioeconomic differences in these conversations, social network characteristics are a likely mechanism given the role of networks in influencing behaviors, including smoking. The purpose of the current study is to investigate whether selected network characteristics mediate the relationship between socioeconomic status (SES) and conversations about smoking harms and cessation benefits. Data for this research came from a convenience sample of adult smokers in the U.S. At baseline, participants reported their egocentric network characteristics and received a 14-day supply of cigarettes with packs modified to include cessation messages on the inside and/or outside of their packs. Each night for 14 days, participants completed a survey that queried their conversations about smoking and cessation with network members in the prior 24 hours. Generalized

[9]Lambert, V.L., Thrasher, J.F., Leal, D.F., Davis, R.D., and Yang, C-H. To be submitted to *Nicotine and Tobacco Research.*

structural equation models estimated the mediation models, and bootstrapped confidence intervals estimated the indirect effects of income and education on conversations about smoking harms and cessation through network characteristics. Contrary to prior research, low SES smokers in the current study reported more conversations about smoking and cessation with their network members. In an unadjusted model, network disapproval of smoking led to more conversations for high SES smokers. Lower SES smokers' close network members appear to be resources for discussing smoking and cessation. Interventions aimed at low SES smokers may consider involving their closest network members and ensuring network members have the tools and information needed to helpful in their efforts to support smokers' cessation attempts.

Introduction

Despite decades of population-level antismoking interventions and significant declines in overall smoking prevalence in the United States, substantial socioeconomic disparities persist and have even increased in smoking prevalence,[1–5] cessation rates,[4,6–10] morbidity,[11,12] and mortality.[12–17] Social and environmental factors – particularly socioeconomic status (SES) – are key contributors to these smoking-related inequities, even more so than individual-level risk factors.[18] Lower SES smokers struggle more with quitting because of social factors, such as more relationships with other smokers,[9,19–22] exposure to pro-smoking norms,[23] and low general and cessation-specific social support.[21,22,24,25]

Conversations about smoking harms and cessation are social behaviors consistently associated with quit attempts.[26–29] Education is positively associated with

conversations about cigarette warning labels[26,29] and interpersonal pressures to quit that follow from exposure to antismoking TV ads.[30] Evidence for the association between income and conversations about smoking harms and cessation is more mixed.[26,29–31] However, U.S. adults with higher income have more people with whom they report discussing important matters.[32] Hence, social network characteristics likely help to explain SES differences in conversations about smoking and cessation. However, no studies have investigated whether social network characteristics mediate SES effects on these conversations.

Smoking norms within networks may mediate SES differences in conversations about smoking and cessation. Lower SES smokers report less social pressure to quit,[33,34] fewer social consequences for continuing to smoke,[35,36] and live in environments where smoking is normalized.[36–38] Two studies found that lower SES smokers perceived relatively higher social acceptability of smoking,[33,39] and another found no significant association with SES.[40] Hence, network smoking disapproval may help explain the relationship between SES and cessation-related behaviors.

The prevalence of smoking in one's social environment, also influence smokers' ability to quit.[41–43] Lower SES smokers have more smokers in their networks.[42,44,45] This reflects the phenomenon of network homophily, such that networks comprise people who are similar, including in age, sex, and education.[46,47,48] Since SES is negatively associated with smoking status, lower SES smokers should have relatively higher numbers of smokers in their networks. While lower SES smokers report high prevalence of network or community smoking as a barrier to cessation,[24,49] evidence is mixed on whether

smoking among network members mediates the relationship between SES and cessation-related outcomes.[19,45]

One of the most well documented network differences by SES is network size. People with few financial resources have smaller networks,[50–53] likely because of exclusion from certain social settings (e.g., educational institutions, leisure activities and organizations),[54,55] and the detrimental effects of socioeconomic hardship on relationships.[56–58] Moreover, multiple studies have found education is positively associated with the size of discussion networks (i.e., the people with whom one has discussed important matters in the last six months).[32,51,53,59–61] Moreover, network size is positively associated with social support[62] and seeking health information from social networks.[63,64] Therefore, network size may mediate the relationship between SES and conversations about smoking harms and cessation, which may be indicative of seeking health information or social support for smoking.

In the current study, we investigated SES differences in the number of conversations about smoking harms and cessation benefits after exposure to novel antismoking messages as well as social network mechanisms for these differences. We measured egocentric networks, which are networks centered around a single study participant (referred to in network literature as an ego), who are surrounded by network alters, the people within each participant's network.[65] Based on the literature described above, we hypothesize that participant SES (income and education) will be positively associated with network size, the number of alters who disapprove of smoking, and the number of conversations about smoking harms and cessation benefits with alters. We also hypothesize that SES (income and education) will be inversely associated with the

number of network smokers. Finally, we hypothesize that these network characteristics (size, number of alters who disapprove of smoking, and number of smokers) will mediate the relationship between SES and the number of conversations about smoking harms and cessation with alters (See Figure 1).

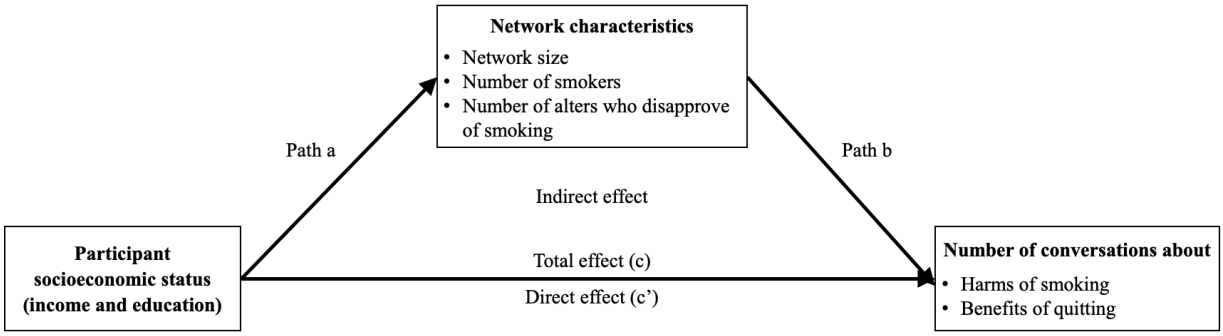


Figure 5.1 Conceptual model

Methods

Sample and recruitment

Data came from a between-subjects randomized controlled trial with adult smokers in the United States. Participants were given a 14-day supply of their preferred cigarette brand with the health warning labels on packs modified to reflect four experimental conditions, all of which were novel relative to current messages on U.S. packs. Labeling effects on key outcomes were mostly not statistically significant and the weakest effects were found for the talking outcomes studied here[10].[66] Data were collected

[10] The current study does not focus on messaging effects for several reasons: 1) Across all conditions, participants were exposed to novel messages on or in cigarette packs that likely all sparked some conversations about smoking harms and cessation, even the control group [88]. 2) The current analysis aims to isolate the social network conditions that encourage conversations about smoking harms and cessation, separate from messaging effects. 3) The current study was likely not adequately powered to assess the effects of the four message conditions on conversations about smoking and cessation, which is an infrequent behavior [88]. Power for this study was lower than expected due to high interclass correlation

from June 28th, 2019 to July 6th, 2021, with participants recruited from South Carolina, North Carolina, and New York state, using multiple recruitment methods, such as intercept recruitment in low-income areas, to ensure variability in participant SES.

Adult smokers (i.e., ≥18 years old) were eligible if they spoke and read English, reported smoking at least 100 cigarettes in their lifetime and at least 10 cigarettes daily in the prior month. Smokers who used other nicotine products in the prior month were ineligible due to challenges around assessing compensatory behaviors involving use of other nicotine products when reducing cigarettes. Full details about the sample and recruitment are described elsewhere.[66] All study procedures were approved by the University of South Carolina's institutional review board.

Procedures

At baseline, participants completed a self-administered survey, after which study staff administered a survey on their egocentric networks (i.e., personal networks of the single study participant [ego][65]). Immediately after the baseline assessments, participants began a 14-day period during which they completed one survey each night to assess conversations about smoking harms and cessation benefits.

coefficients despite relatively strong effect sizes; hence, the sample size is not adequate for detecting what may be relatively small effects. 4) Because our measures of conversations were not limited to conversations sparked by or about the messages, we captured conversations that were not necessarily a direct result of message exposure.

Measures

Independent variables

Participant socioeconomic status

Household income was assessed by asking, "Which of the following categories best describes your ANNUAL household income, that is the total income before taxes, or gross income, of all persons in your household combined, for one year?" Response options included, "Under $10,000", "$10,000-29,999", "$30,000-44,999", "$45,000-59,999", "$60,000-74,999", "$75,000-99,999", "$100,000-149,999", "$150,000 and over", and "Prefer not to answer".[67]

Education of participants was assessed by asking, "What is the highest level of formal education that you have completed?" Response options included, "Grade school or some high school", "Completed high school", "Technical / trade school or community college", "Some university, no degree", "Completed university degree", and "Post-graduate degree" [67]. Responses were categorized as low (≤ High school), moderate (Technical/trade school or community college or some university), and high (Completed university or post-graduate degree), as in other studies that have used this measure.[7,44,68,69]

Mediators

Network generator. Our network name generator asked, "Of the people with whom you are closest, who have you spent the most time with in the past two weeks?" Participants could name up to 5 people, which appears to be the ideal number to

maximize non-redundant network information while minimizing participant burden,[70] and were not allowed to name children younger than 3 years old.

The purpose of our network generator was to elicit alters with whom participants felt close and were likely to interact over the study period. Thus, it was both affect-based and interaction-based, which are two popular types of name generators in egocentric network studies.[65] Other studies have taken a similar approach of combining affect and interaction name generators (cf. [71]).

Network characteristics. To measure alter characteristics, all attributes of each alter were assessed before asking questions about the characteristics of subsequently named alters. *Network size* is the sum of the number of alters each participant named (ranging =0 – 5). The smoking status of each alter was assessed by asking, "To the best of your knowledge, does [name of alter] smoke cigarettes?", from which we summed the *number of smokers* (range= 0 – 5). Smoking approval was assessed for each alter by asking, "What does [name of alter] think about your smoking?" (1="Strongly disapproves" – 5="Strongly approves"), based on measures of smoking disapproval in prior research.[39,40,72] We dichotomized this variable for each alter to indicate disapproval of smoking (i.e., 1= Strongly disapproves or disapproves and 0 = Neutral, Approves, or Strongly approves), then summed the *number of alters disapproving of smoking* (range=0 – 5).

Dependent variables

The number of conversations about the dangers of smoking and *of conversations about the benefits of quitting* were assessed in three steps: 1. the daily survey asked

participants: "In the last 24 hours, have you talked with [list of alters named at baseline] about good or bad things about smoking or quitting?" (0=No, 1=Yes); 2. if a participant selected "Yes", the survey repeated the same question for each alter (e.g., "In the last 24 hours, have you talked with [alter name] about good or bad things about smoking or quitting?" (0=No, 1=Yes)).[11] 3. for each alter who whom a participant reported talking about smoking or quitting, the participant was asked what they talked about with that alter from a list of potential topics (e.g., "How much you like smoking", "Dangers of smoking to you", "Benefits of quitting smoking"). Our analyses considered only conversations about the "Dangers of smoking to you" or "Benefits of quitting smoking" because of evidence that these topics are more strongly associated with cessation outcomes than other topics.[28,73,74] For each day, these two topics were evaluated separately and coded dichotomously (i.e., 0=Did not discuss topic on that day; 1=Discussed topic on that day). When then summed the number of days participants reported talking about each topic (range= 0 – 14).

Control variables (assessed at baseline).

Control variables in adjusted models included *cigarettes per day*, *recent quit attempts* (i.e., in the past year), *intention to quit smoking* in the next six months (1=Yes; 0=No), *age* (continuous), *sex assigned at birth* (female or male), *race* (White, Black or African American, Latino/Latina/Latinx, Asian, Native Hawaiian or Pacific Islander, American Indian or Alaska Native, or multiple races/ethnicities), *study site* (New York

[11] To reduce potential bias from prompting participants to think about the cigarette labeling messages by constantly asking them about the messages in the nightly surveys, the measures did not explicitly ask about conversations about the cigarette package labels.

vs. South and North Carolina), *study period* (before vs. during the COVID-19 pandemic), and e*xperimental message condition*.

Analysis

Using Stata version 17, unadjusted and adjusted generalized structural equation models (GSEM) estimated direct, indirect, and total effects for our mediation models. In these models, conversations and mediating variables were regressed on all covariates. We produced bootstrapped confidence intervals for all indirect effects with the percentile bootstrap approach[75] using 1,000 resamples. We considered indirect effects significant if the confidence intervals did not include zero.

Conversations about smoking harms and quitting benefits were assessed as separate dependent variables, and income and education were assessed as separate independent variables. We assessed income as a continuous variable for simplicity in mediation models and ease of interpreting results. As a sensitivity analysis, we ran all models using a trichotomized income measure, as has often been done,[7,44,68,69] and found that neither the significance nor the direction of any results changed compared to using continuous income (See Appendix).

Fourteen percent of the data for the dependent variables were missing. Because using multiple imputation methods with GSEM is not possible in Stata, to control for potential effects of missing surveys on the outcomes, all models adjusted for the number of surveys participants provided (1-14). When including both closeness and frequency of communication as statistical controls, results (available upon request) were consistent in valence and statistical significance with the results reported here.

Results

Sample characteristics and descriptive statistics

The analytic sample (i.e., participants who provided information for both income and education; N=351; see Table 5.1) was mostly female (61.54%), white (81.48%), had greater than high school education (58%) and a household income of less than $45,000 per year (63.63%). On average, participants reported talking with alters about the dangers of smoking on one day throughout the study period (Mean=1.15, SD=2.07; Median=0) and about the benefits of quitting slightly more often (Mean=1.42, SD=2.18; Median=0).

Table 5.1 Key variable descriptive statistics. (N=351)[1]

	Mean (SD) or %
Individual (participant) characteristics	
Household Income (N=352)	
Under $10,000	15.91%
$10,000-$29,999	28.12%
$30,000-$44,999	19.60%
$45,000-$59,999	15.34%
$60,000-$74,999	9.09%
$75,000-$99,999	5.11%
$100,000-$149,999	5.68%
$150,000 and over	1.14%
Education (N=361)	
High school or less	42.38%
Technical/trade school, community college, or some university	41.27%
Completed university or post-graduate degree	16.34%
Age	44.06 (12.14)
Sex at birth	
Female	61.54%
Male	38.46%
Race	
White	81.48%
Black or African American	12.82%
Latino/Latina/Latinx	2.85%
Asian	0.57%
Native Hawaiian or Pacific Islander	0.28%

American Indian or Alaska Native	1.14%
Multiple races/ethnicities	0.85%
Cigarettes per day	21.54 (9.17)
Recent quit attempt (past year)	
Yes	29.91%
No	69.52%
Missing (includes don't know)	0.6%
Intention to quit within 6 months	
Yes	32.48%
No or don't know	67.52%
Location	
NY	54.70%
SC/NC	45.30%
Study period	
Pre-COVID	55.27%
During COVID	44.73%
Experimental message condition	
Control	28.21%
Inserts	23.36%
GHWLs	23.65%
Inserts + GHWLs	24.79%
Daily surveys completed (range 1-15)	12.36 (2.47)
Network characteristics[2]	
Network size (range 1-5)	3.22 (1.35)
1 alter	13.39
2 alters	18.23
3 alters	25.07
4 alters	19.94
5 alters	23.36
Number of current smokers (range 0-5)	1.49 (1.13)
Number of alters who disapprove of smoking (range 0-5)	1.47 (1.23)
Number of conversations with alters	
About dangers of smoking (range 0-14)	1.15 (2.07)
About benefits of quitting (range 0-14)	1.42 (2.18)

Notes:
[1]Descriptives for variables other than income and education are only from people who provided data for both income and education.
[2]Networks were elicited through a name generator that asked participants to name up to five people (alters) with whom they felt closest and spent the most time with in the prior two weeks. Then, participants answered several questions about characteristics of their network alters.

Network size as mediator

In models with income as an independent variable, network size as a mediator, and conversations about smoking harms as the dependent variable (Model 1, Table 5.2), income was positively associated network size, but only in the unadjusted model (Crude b=0.04, p<0.05). Income was negatively associated with (Crude b=-0.10, p<0.001; Adjusted b=-0.11, p<0.001) and network size was positively with (Crude b=0.12, p<0.01; Adjusted b=0.14, p<0.001) conversations about smoking harms. In the models with income predicting conversations about quitting benefits and network size as the mediator (Model 1, Table 5.3), a similar pattern of statistically significant results was found, though network size was unassociated with this outcome.

In the models with education as an independent variable, network size as a mediator, and conversations about smoking harms as the dependent variable (Model 1, Table 5.2), high education (vs. low) was negatively associated with (Crude b=-0.31, p<0.05; Adjusted b=-0.36, p<0.05) and network size was positively associated with (Crude b=0.10, p<0.01 Adjusted b=0.14, p<0.001) conversations about smoking harms. In the models with education predicting conversations about the quitting benefits (Model 1, Table 5.3), no effects were statistically significant.

Number of network smokers as a mediator

In the models with income as an independent variable, the number of network smokers as the mediator, and conversations about smoking harms as the dependent variable (Model 2, Table 5.2), income negatively associated with (Crude b=-0.08, p<0.01; Adjusted b=-0.10, p<0.01) and network smokers was positively associated with

(Crude b=0.10, p<0.05; Adjusted b=0.12, p<0.01) conversations about smoking harms. In the models with income predicting conversations about quitting benefits and network smokers as the mediator (Model 2, Table 5.3), a similar pattern of statistically significant results was found.

In the models with education as an independent variable, the number of network smokers as the mediator, and the number of conversations about smoking harms as the dependent variable (Model 2, Table 5.2), high education was negatively associated with (Adjusted b=-0.35, p<0.05) and network smokers was positively associated with (Crude b=0.12, p<0.05 Adjusted b=0.15, p<0.001) conversations about smoking harms. In the models with education predicting conversations about quitting benefits and network smokers as the mediator (Model 2, Table 5.3), a similar pattern of statistically significant results was found.

Number of alters who disapprove of smoking as a mediator

In the models with income as an independent variable, the number of alters who disapprove of smoking as the mediator, and the number conversations about smoking harms as the dependent variable (Model 3, Table 5.2), income was positively associated with number of alters who disapproved of smoking (Crude b=0.08, p<0.001; Adjusted b=0.05, p<0.05). Income was negatively associated with (Crude b=-0.10, p<0.001; Adjusted b=-0.12, p<0.001) and number of alters who disapproved of smoking was positively associated with (Crude b=0.17, p<0.001; Adjusted b=0.16, p<0.001) conversations about smoking harms. The indirect effect of income on conversations about smoking harms through alter smoking disapproval was positive but was only statistically

significant before adjusting for covariates (b=0.03, 95% CIs= 0.002, 0.062). In the models with income predicting the number of conversations about quitting benefits and alter smoking disapproval as the mediator (Model 3, Table 5.3), a similar pattern of statistically significant results was found except that alter disapproval of smoking was only significantly associated with conversations about cessation benefits in the unadjusted model (Crude b=0.08, $p<0.05$) and the indirect effect of income through alters who disapprove of smoking was not significant.

In the models with education as an independent variable, number of alters who disapprove of smoking as the mediator, and the number of conversations about smoking harms as the dependent variable (Model 3, Table 5.2), high education was negatively associated with (Adjusted b=-0.32, $p<0.05$) and alter disapproval of smoking was positively associated with (Crude b=0.15, $p<0.001$; Adjusted b=0.15, $p<0.001$) conversations about smoking harms. In the models with education predicting number of conversations about quitting benefits and alter smoking disapproval as the mediator (Model 3, Table 5.3), none of the results were statistically significant.

Table 5.2 Direct and indirect effects of SES on number of conversations about smoking harms

	Crude						Adjusted					
	Path a		**Path b**		**Path c'**		**Path a**		**Path b**		**Path c'**	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Model 1: Mediator network size												
Income (continuous)	0.04*	0.02	0.12**	0.04	-0.10***	0.03	0.02	0.02	0.14***	0.04	-0.11***	0.03
Moderate education	0.07	0.06	0.10**	0.04	-0.14	0.11	0.01	0.07	0.14***	0.04	-0.18	0.12
High education	0.12	0.08	0.10**	0.04	-0.31*	0.11	0.07	0.09	0.14***	0.04	-0.36*	0.16
Model 2: Mediator number of network smokers												
Income (continuous)	-0.03	0.03	0.10*	0.04	-0.08**	0.03	-0.02	0.03	0.12**	0.04	-0.10**	0.03
Moderate education	0.01	0.10	0.12*	0.04	-0.11	0.11	0.05	0.10	0.15***	0.04	-0.17	0.12
High education	0.06	0.12	0.12*	0.04	-0.29	0.15	0.11	0.13	0.15***	0.04	-0.35*	0.16
Model 3: Mediator number of alters who disapprove of smoking												
Income (continuous)†	0.08***	0.02	0.17***	0.04	-0.10***	0.03	0.05*	0.03	0.16***	0.04	-0.12***	0.03
Moderate education	0.04	0.10	0.15***	0.04	-0.11	0.11	-0.08	0.10	0.15***	0.04	-0.13	0.12
High education	0.11	0.12	0.15***	0.04	-0.3	0.15	-0.01	0.13	0.15***	0.04	-0.32*	0.16

*p ≤ 0.05, **p ≤ 0.01, ***p≤ 0.001

†The only statistically significant indirect effect was for the unadjusted model of the effects of income on conversation about smoking harms through network smoking disapproval (b=0.03, 95% CIs= 0.002, 0.062).

Notes: Generalized Structural Equation Models were used for all analyses. Bootstrapped confidence intervals based on percentile method were used to estimate indirect effects. Crude models controlled for total days in study. Adjusted models controlled for total days in study, cigarettes per day, quit attempt in past 12 months, intention to quit within next 6 months, location, pre vs. during

COVID, experimental message condition, age, sex at birth, and race. Path a= effect of independent variable on mediator, path b=effect of mediator on dependent variable, path c'=direct effect

Table 5.3 Direct and indirect effects of SES on number of conversations about the benefits of quitting

	Crude						**Adjusted**					
	Path a		**Path b**		**Path c'**		**Path a**		**Path b**		**Path c'**	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Model 1: Mediator network size												
Income (continuous)	0.04*	0.02	0.02	0.03	-0.08**	0.03	0.02	0.02	0.02	0.04	-0.13***	0.03
Moderate education	0.07	0.06	0.01	0.03	-0.06	0.10	0.01	0.07	0.02	0.04	-0.15	0.10
High education	0.12	0.12	0.01	0.03	-0.19	0.14	0.07	0.09	0.02	0.04	-0.27	0.14
Model 2: Mediator number of network smokers												
Income (continuous)	-0.03	0.03	0.08*	0.04	-0.08**	0.03	-0.02	0.03	0.09*	0.04	-0.12***	0.03
Moderate education	0.01	0.10	0.10*	0.04	-0.06	0.10	0.05	0.10	0.12**	0.04	-0.16	0.10
High education	0.06	0.12	0.10*	0.04	-0.20	0.14	0.11	0.13	0.12**	0.04	-0.29*	0.14
Model 3: Mediator number of alters who disapprove of smoking												
Income (continuous)	0.08***	0.02	0.08*	0.04	-0.09***	0.03	0.05*	0.03	0.06	0.04	-0.13***	0.03
Moderate education	0.04	0.10	0.06	0.04	-0.07	0.10	-0.08	0.10	0.05	0.04	-0.14	0.10
High education	0.11	0.12	0.06	0.04	-0.2	0.14	-0.01	0.13	0.05	0.04	-0.26	0.14

*p ≤ 0.05, **p ≤ 0.01, ***p≤ 0.001

Notes: Generalized Structural Equation Models were used for all analyses. Bootstrapped confidence intervals based on percentile method were used to estimate indirect effects. Crude models controlled for total days in study. Adjusted models controlled for total days in study, cigarettes per day, quit attempt in past 12 months, intention to quit within next 6 months, location, pre vs. during COVID, experimental message condition, age, sex at birth, and race. Path a= effect of independent variable on mediator, path b=effect of mediator on dependent variable, path c'=direct effect

Discussion

In the current study assessing the effects of SES on conversations about smoking harms and quitting benefits with close network alters and indirect effects mediated through key network characteristics, there was no evidence for mediation by any network characteristic in the adjusted models, and many of our other hypotheses were only partially supported or unsupported by our results.

Contrary to our hypothesis and our prior research (in much larger samples),[26,29] smokers' income and education were negatively associated with conversations about smoking harms and benefits of quitting. In our current study, we assessed conversations with a limited number of participants' strongest alters. Because people with lower SES have small, close, and frequently contacted networks, lower SES smokers in the current study may have relied more on their close alters for conversations about smoking and cessation. If we had measured larger networks that included weaker ties, we may have found that higher SES smokers reported more of these conversations overall because they tend to have larger networks and more social ties that are weak. Furthermore, people often talk to less close alters about important matters,[76] and these types of alters are often less available for people with lower SES.[77,78] Future research should compare conversations about smoking and cessation by SES using larger networks and assess if the impact of conversations on subsequent quitting varies by the strength of ties (e.g., perceived closeness) of the alters with whom they talk.

Other methodological differences between our study and prior studies could have also influenced our unexpected finding that SES was inversely associated with

conversations about smoking harms and cessation. Previous studies assessed conversations about health warning labels after months or years of exposure to the same warnings, asked participants to recall conversations in the past month, asked specifically about conversations about the warnings, and did not directly measure smokers' network members.[26,29] Compared to our study, these approaches may have resulted in less accurate reporting of conversations and networks; however, they may have also been more generalizable by assessing conversations over a longer period and not limiting conversations to those with close alters.

Regardless of the reason for this unexpected result, our finding that low SES smokers talk more with their closest – and likely most influential– alters presents an opportunity for intervention. Interventions might consider encouraging lower SES smokers' close network members to get involved in cessation support or creating messaging specifically for these close alters that assists them in having supportive and effective conversations about smoking harms and quitting benefits.

Some of our hypotheses regarding associations between SES and network attribute were supported by our findings, but others were not. As we hypothesized, income was positively associated with the number of alters disapproving of smoking; however, unlike we hypothesized education was not associated with this variable. Previous research has found that smokers with higher income[39] have networks more disapproving of smoking as well as positive associations between education and network smoking disapproval,[79] network support for quitting,[42] and social pressure to quit.[34] However, these prior studies had much larger samples (n=1,549-9,058) compared to our

present study, which may not have been powered to detect effects of education on smoking disapproval.

Contrary to our hypotheses and prior research,[42,44,45] neither income nor education were associated with the number of alters who were smokers. Again, our study likely had less power to assess these associations than those prior studies with large samples (n=481-6,321). In addition, if we had assessed larger networks with weaker ties, we may have found SES differences in network smoking as people with higher SES are more likely to have larger networks of people who are dissimilar to themselves (e.g., non-smokers).[46–48]

Our hypothesis that SES would be positively associated with network size was partially supported. In line with prior research,[50–53] participant income was positively associated with network size in models that did not adjust for covariates. Though the coefficients were positive, participant education was not significantly associated with network size in any models, which contrasts with multiple studies that have found education was positively associated with network size.[32,50,51,53,59–61,80] However, these prior studies measured networks with whom participants discussed important matters[51,59,60] or close alters outside the home.[50,53] While education may affect the number of alters available to discuss important matters and close alters outside the home, it may not influence the number of closest and frequently contacted alters like those in our study. Indeed, one prior study found that, while education was positively associated with the size of broad networks, it was unassociated with the number of extremely close alters with whom participants felt they could not live without.[80]

Only one of our hypotheses regarding the mediating effect of network characteristics in the relationship between SES and conversations about smoking harms and cessation was supported and only in an unadjusted model. Income was positively associated with the number of alters disapproving of smoking, which was in turn associated with the number of conversations about smoking harms. Though lower income smokers in our study reported more conversations about smoking harms and cessation with their closest alters, higher income smokers benefitted more from having close networks that were disapproving of smoking. This finding reflects the evidence on network homogeneity and behavior change as people with lower SES have more homogeneous networks, which often come with highly entrenched behaviors and norms that make behavior change more difficult.[81]

Overall, the strength of networks we measured and overall low SES of our sample compared to the general population likely helps explain many of our unsupported hypotheses. Though previous studies that informed our hypotheses measured much larger networks or networks of alters who were not as close or important the alters in our study, we assessed conversations with a limited number of very close alters. People with lower SES tend to have relatively few weak ties, rely on small, strong networks for support,[77,78] and communicate with their networks more frequently.[46,50,51,82] Hence, it is not altogether surprising that we failed to find consistent differences by SES in network size or that lower SES smokers reported more conversations about smoking harms and cessation with their closest alters.

Furthermore, our sample had lower income and education compared to the U.S. population. Whereas 16% percent of our sample completed a bachelor's degree or higher,

33.7% of the U.S. population fall in this category.[83] In our study, 11.9% of participants had a household income of $75,000 or higher; however, 46.8% of the U.S. population fell into this category in 2020.[84] Since people with lower SES tend to have more homogenous networks,[46–48] the lower SES of our sample likely diminished our ability to detect network differences by SES compared to research among the general population that informed our hypotheses.

Limitations

Out study has other limitations with implications for our results. We were unable to meaningfully analyze average perceived closeness of participants' alters because the network generator asked participants to name people with whom they felt the closest. While this limited our ability to understand the role of perceived alter closeness in our models, it also resulted in networks of alters who were most likely to influence smokers to quit.[85] We also did not assess connections between alters, which is important for understanding social influence on behaviors. Furthermore, we used a convenience sample that was not representative of U.S. smokers, limiting generalizability of our results. Our sample included few non-white or Latino/a/x smokers. While it is unclear what effect this might have had on the relationships we assessed, there is evidence that social network characteristics vary by race and ethnicity.[32,50,52,86] Because non-white smokers - especially Black smokers - are disproportionately impacted by smoking-related

diseases,[13,87] it is crucial to expand this area of research with samples that represent non-white smokers and are powered to assess the potential moderation effects of race.

Conclusion

In conclusion, our study found that, among small egocentric networks of close alters, lower SES smokers reported more conversations about smoking harms and cessation benefits than higher SES smokers. However, greater network disapproval of smoking led to more conversations for higher SES smokers. While previous research suggests high SES smokers have more conversations about cessation messages, or study implies that low SES smokers have more conversations about smoking harms and cessation with their closest network members –the people who are most likely to support and influence cessation. Interventions seeking to reduce cessation inequities for low SES smokers may consider encouraging conversations about smoking harms and cessation benefits with close alters, though such interventions may require training in the provision of supportive and effective advice. Future studies should further this research by determining the prevalence of these conversations between closer and weaker ties as well as whether the closeness of conversation partners matters for influencing cessation.

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Appendix

Table 5.4 Direct and indirect effects of categorical income on number of conversations about smoking harms

	Crude						Adjusted					
	Path a		**Path b**		**Path c'**		**Path a**		**Path b**		**Path c'**	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Model 1: Mediator network size												
Moderate income	0.11	0.07	0.12**	0.04	-0.58***	0.12	0.04	0.07	0.14***	0.04	-0.66***	0.13
High income	0.20**	0.08	0.12**	0.04	-0.14*	0.13	0.13	0.08	0.14***	0.04	-0.39**	0.14
Model 2: Mediator number of network smokers												
Moderate income	-0.02	0.10	0.11*	0.04	-0.53***	0.12	-0.02	0.11	0.13**	0.04	-0.63***	0.13
High income	-0.09	0.12	0.11*	0.04	-0.23	0.13	-0.06	0.13	0.13**	0.04	-0.32*	0.14
Model 3: Mediator number of alters who disapprove of smoking												
Moderate income	0.21*	0.10	0.17***	0.04	-0.59***	0.12	0.10	0.11	0.16***	0.04	-0.66***	0.13
High income†	0.38**	0.11	0.17***	0.04	-0.33*	0.13	0.24	0.13	0.16***	0.04	-0.39**	0.14

*p ≤ 0.05, **p ≤ 0.01, ***p≤ 0.001

†The only statistically significant indirect effect was for the unadjusted model of the effects of high income on conversation about smoking harms through network smoking disapproval (b=0.12, 95% CIs=0.01, 0.28).

Notes: Generalized Structural Equation Models were used for all analyses. Bootstrapped confidence intervals based on percentile method were used to estimate indirect effects. Moderate income=$30,000-$59,000. High income=≥$60,000. Crude models controlled for total days in study. Adjusted models controlled for total days in study, cigarettes per day, quit attempt in past 12 months, intention to quit within next 6 months, location, pre vs. during COVID, experimental message condition, age, sex at birth, and race. Path a= effect of independent variable on mediator, path b=effect of mediator on dependent variable, path c'=direct effect

Table 5.5 Direct and indirect effects of categorical income on number of conversations about the benefits of quitting

	Crude						Adjusted					
	Path a		**Path b**		**Path c'**		**Path a**		**Path b**		**Path c'**	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Model 1: Mediator network size												
Moderate income	0.11	0.07	0.02	0.03	-0.38***	0.10	0.05	0.07	0.02	0.04	-0.52***	0.11
High income	0. 20**	0.08	0.02	0.03	-0.28*	0.12	0.13	0.08	0.02	0.04	-0.47**	0.13
Model 2: Mediator number of network smokers												
Moderate income	-0.02	0.10	0.08*	0.04	-0.37***	0.10	-0.02	0.11	0.10*	0.04	-0.52***	0.11
High income	-0.09	0.12	0.08*	0.04	-0.26*	0.12	-0.06	0.13	0.10*	0.04	-0.45***	0.13
Model 3: Mediator number of alters who disapprove of smoking												
Moderate income	0.21*	0.10	0.08*	0.04	-0.40***	0.11	0.10	0.11	0.06	0.04	-0.54***	0.11
High income	0.38**	0.11	0.08*	0.04	-0.31*	0.12	0.24	0.13	0.06	0.04	-0.49***	0.13

*p ≤ 0.05, **p ≤ 0.01, ***p≤ 0.001

Notes: Generalized Structural Equation Models were used for all analyses. Bootstrapped confidence intervals based on percentile method were used to estimate indirect effects. Moderate income=$30,000-$59,000. High income=≥$60,000. Crude models controlled for total days in study. Adjusted models controlled for total days in study, cigarettes per day, quit attempt in past 12 months, intention to quit within next 6 months, location, pre vs. during COVID, experimental message condition, age, sex at birth, and race. Path a= effect of independent variable on mediator, path b=effect of mediator on dependent variable, path c'=direct effect

Chapter 6

Conclusions and Recommendations

This dissertation examined the relationships between network characteristics and conversations about smoking and cessation, including the role of networks in explaining how SES appears to influence the occurrence of these conversations. Within the most frequently contacted, close egocentric networks, smokers with more network alters who disapproved of smoking and with more smokers were more likely to have conversations about smoking and cessation. These findings corroborate much research that has found perceived smoking disapproval encourages cessation-related outcomes (Brown et al., 2009; Hammond et al., 2006; Hosking et al., 2009; Rennen et al., 2014; Schoenaker et al., 2018; van den Putte et al., 2005). However, our results also contrast with some research that has found being around other smokers makes it more difficult to quit smoking (Blok et al., 2017; Hitchman, Fong, Zanna, Thrasher, & Laux, 2014; Thomas et al., 2019). Though conversations about smoking and cessation are associated with quit attempts (Lambert et al., 2020; Morgan et al., 2018; Thrasher et al., 2016; van den Putte et al., 2011), more research is needed to understand if having these conversations with smokers diminishes their effectiveness.

Compared to high SES smokers in the current study, low SES smokers reported more conversations about smoking and cessation within their strong egocentric networks, which is in stark contrast to previous research that has found higher SES smokers report more conversations about health warning labels on cigarette packs (Lambert et al., 2020;

Thrasher et al., 2016) and other cessation messages (Dunlop et al., 2014). This unexpected finding was likely due to the small, very strong (i.e., close and frequently contacted) networks measured in this study and the relatively low income and education of our sample compared to previous studies. Nonetheless, our finding that low SES smokers have more conversations about smoking and cessation suggests that low SES smokers have networks that could provide support for cessation, and these networks may be leveraged in cessation interventions to promote more equitable cessation outcomes.

Though low SES smokers in our study reported more conversations about smoking and cessation, network disapproval of smoking led to more conversations for high than low SES smokers. This suggests that injunctive smoking norms may have a stronger impact on cessation among high SES smokers, which could help explain disparities cessation outcomes, in particular, disparities in the effectiveness of cessation interventions (Niederdeppe et al., 2008).

Limitations

This study had several limitations with implications for interpreting the results. First, the relatively small sample size likely resulted in inadequate powered to evaluate some associations between SES, network characteristics, and conversations about smoking and cessation, all of which may have small effect sizes. Prior research on associations between network characteristics and cessation outcomes as well as prior research on SES and network characteristics have had much larger samples sizes than the current study. Moreover, other studies that have analyzed conversations about smoking and cessation as dependent variables asked about conversations that occurred over longer periods of time (e.g., Brewer et al., 2016 assessed conversations for 1 month; van den

Putte et al., 2016 assessed that occurred over 3 months), so our study had less opportunity to capture these conversations compared to prior studies, limiting our ability to detect effects. Future research with larger samples and/or longer study periods may be needed to better assess the relationships between some network attributes and conversations about smoking and cessation. Another limitation of the current study was that it did not assess connections between alters, which is important for understanding social network influences on behaviors. Future research should investigate whether these alter-alter connections (i.e., network density) encourage more conversations about smoking and cessation. Furthermore, the small, extremely close networks we measured likely limited our ability to detect the effects of some network characteristics (e.g., limited variability in tie strength) on conversations about smoking and cessation as well as differences in networks by SES. Therefore, the results cannot be generalized to larger networks that consist of both strong and weaker social ties, which may have different impacts on conversations about smoking and cessation. However, the networks in the current study consisted of alters with whom smokers had strong ties and, thus, who were likely to have the greatest influence on behavior change (Latané, 1996; Nowak et al., 1990).

The generalizability of the study results is also limited because of the sample. We used a convenience sample that was not representative of U.S. smokers. Relative to the general population of smokers, our sample included relatively few non-white or Latino/a/x smokers. While it is unclear what effect these attributes might have had on the relationships we assessed, there is evidence that social network characteristics vary by race and ethnicity (Albert & Hajdu, 2020; Alwin et al., 2018; Brashears, 2011; Schafer & Vargas, 2016). Future research should be conducted among larger, more representative

samples that are well-powered for assessing the potential moderating effects of race and other effects of sociodemographic characteristics. Because non-white smokers - especially Black smokers - are disproportionately impacted by smoking-related diseases (Glei et al., 2020; Lawrence et al., 2022), it is crucial to expand this area of research to better represent those groups.

Implications and Future Research

This dissertation provides the most comprehensive analysis to date of the social factors influencing conversations about smoking and cessation. It also provides the first assessment "real time" assessment of these conversations under conditions of repeated exposure to novel cessation messages. The findings provide insight into the social contexts that encourage these conversations and suggest interventions seeking to reduce cessation inequities for low SES smokers may encourage conversations about smoking and cessation with close alters– who are most likely to influence cessation– as a source of supportive and effective advice.

Building on these findings, future research should examine how, why, and by whom conversations about smoking and cessation are initiated and whether conversations with alters of specific characteristics are associated with subsequent quitting. Though the current study was conducted among close network alters who are most likely to influence cessation through their conversations, future research may further this line of research by examining broader networks that include weaker social ties.

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Appendix A: Aim 1 Results Stratified Before and During COVID-19 Outbreak

Table A.1 Talking with alters about the harms of smoking before and during COVID-19 pandemic

Pre-COVID-19						
	Bivariate results OR (95% CI) n=365-366		One IV + controls AOR (95% CI)[1] n=348-349		Full model (All IVs + controls) AOR (95% CI) [2] n=348	
Network size	0.99	(0.79, 1.28)	1.14	(0.87, 1.50)	**0.56***	(0.35, 0.89)
Has spouse/significant other	0.68	(0.36, 1.28)	0.74	(0.38, 1.52)	0.61	(0.29, 1.24)
Closeness	1.08	(0.66, 1.79)	1.06	(0.62, 1.81)	1.05	(0.58, 1.89)
Frequency of communication	1.08	(0.48, 2.43)	0.99	(0.43, 2.36)	1.24	(0.51, 2.99)
Number of network smokers	1.09	(0.84, 1.42)	1.19	(0. 90, 1.56)	**2.24***	(1.42, 3.54)
Has one or more former smoker	1.18	(0.57, 2.49)	1.48	(0.65, 3.34)	1.64	(0.69, 3.88)
Number of alters disapproving of smoking	1.20	(0.94, 1.53)	**1.36***	(1.05, 1.77)	**2.33****	(1.49, 3.65)
During COVID-19						
	Bivariate results OR (95% CI) n=365-366		One IV + controls AOR (95% CI)[1] n=348-349		Full model (All IVs + controls) AOR (95% CI) [2] n=348	
Network size	1.20	(0.95, 1.52)	1.19	(0.93, 1.54)	1.30	(0.91, 1.86)
Has spouse/significant other	1.86	(0.99, 3.50)	**2.24***	(1.14, 4.37)	1.55	(0.79, 3.08)
Closeness	**1.79***	(1.01, 3.14	**2.30****	(1.28, 4.06)	**2.35***	(1.22, 4.49)
Frequency of communication	1.15	(0. 60, 2.19)	1.35	(0.71, 2.58)	1.09	(0.54, 2.19)

Number of network smokers	1.10	(0.82, 1. 47)	1.06	(0 .80, 1.40)	1.01	(0.71, 1.43)
Has one or more former smoker	0.95	(0.46, 1.93)	0.89	(0.43, 1.83)	0.88	(0.43, 1.80)
Number of alters disapproving of smoking	1.28	(0.99, 1.66)	1.15	(0.90, 1.49)	0.99	(0.71, 1.37)

*p<.05, **p<.01, ***p<0.001

Notes: Results are from analysis of multiple imputed data. Mixed effects logistic regression with multiple imputation for missing data was used to assess relationships between network characteristics and conversations.

OR= odds ratio and AOR= adjusted odds ratio. Adjusted models controlled for day in study, income, education, cigarettes per day, quit attempt in past 12 months, intention to quit within next 6 months, location, pre/during COVID, experimental condition, age, sex at birth, and race.

[1]Each row represents results from a separate adjusted model (network characteristics indicated in the row and all control variables)

[2]Results in this column are from a single model that adjusted for all network characteristics and control variables.

Table A.2 Talking with alters about the benefits of quitting before and during COVID-19 pandemic

Pre-COVID-19						
	Bivariate results OR (95% CI) n=365-366		One IV + controls AOR (95% CI)[1] n=348-349		Full model (All IVs + controls) AOR (95% CI) [2] n=348	
Network size	0.90	(0.72, 1.10)	0.95	(0.74, 1.20)	**0.46*** **	(0.30, 0.70)
Has spouse/significant other	0.92	(0.92, 1.63)	1.10	(0.58, 2.09)	1.02	(0.53, 1.95)
Closeness	1.07	(0.69, 1.67)	1.18	(0.71, 1.89)	1.10	(0.64, 1.88)
Frequency of communication	1.06	(0.50, 2.23)	1.02	(0.46, 2.28)	1.00	(0.44, 2.26)
Number of network smokers	1.11	(0.84, 1.42)	1.20	(0.93, 1.54)	**2.40*** **	(1.53, 3.75)
Has one or more former smoker	1.42	(0.74, 2.72)	1.62	(0.77, 3.39)	**2.59***	(1.17, 5.76)

Number of alters disapproving of smoking	1.03	(0.83, 1.29)	1.12	(0.88, 1.43)	**1.99****	(1.32, 2.99)
During COVID-19						
	Bivariate results OR (95% CI) n=365-366		One IV + controls AOR (95% CI)[1] n=348-349		Full model (All IVs + controls) AOR (95% CI)[2] n=348	
Network size	1.10	(0.88, 1.37)	1.06	(0.85, 1.32)	1.15	(0.84, 1.58)
Has spouse/significant other	1.50	(0.85, 2.64)	**1.83***	(1.01, 3.33)	1.32	(0.73, 2.39)
Closeness	**2.16****	(1.29, 3.57)	**2.62*****	(1.57, 4.35)	**2.97****	(1.56, 4.99)
Frequency of communication	1.10	(0.62, 1.95	1.31	(0.75, 2.28)	0.93	(0.52, 1.67)
Number of network smokers	1.08	(0.82, 1.41)	1.03	(0.79, 1.32)	1.04	(0.76, 1.41)
Has one or more former smoker	1.02	(0.53, 1.94)	1.00	(0.55, 1.89)	1.08	(0.58, 2.01)
Number of alters disapproving of smoking	1.22	(0.97, 1.54)	1.08	(0.87, 1.35)	0.99	(0.73, 1.32)

*p<.05, **p<.01, ***p<0.001

Notes: Results are from analysis of multiple imputed data. Mixed effects logistic regression with multiple imputation for missing data was used to assess relationships between network characteristics and conversations.

OR= odds ratio and AOR= adjusted odds ratio. Adjusted models controlled for day in study, income, education, cigarettes per day, quit attempt in past 12 months, intention to quit within next 6 months, location, pre/during COVID, experimental condition, age, sex at birth, and race.

[1]Each row represents results from a separate adjusted model (network characteristics indicated in the row and all control variables)

[2]Results in this column are from a single model that adjusted for all network characteristics and control variables.