

UNDERSTANDING FACTORS AFFECTING ADHERENCE IN A  
TELEPHONE-BASED INTERVENTION TO REDUCE  
SECONDHAND SMOKE EXPOSURE TO  
CHILDREN:AN EXPLORATORY  
ANALYSIS

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A Thesis  
Submitted to  
the Temple University Graduate Board

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In Partial Fulfillment  
of the Requirements for the Degree  
MASTER OF SCIENCE  
in Epidemiology

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May 2018

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## ABSTRACT

**Background/Purpose:** The Kids Safe and Smokefree (KiSS) trial aimed to reduce secondhand smoke exposure to children. The study used a multifaceted approach that included a pediatric clinic-level intervention, individual behavioral counseling, and community services for nicotine dependence. This secondary analysis focuses on the individual behavioral counseling portion of the intervention. The purpose of this cross-sectional, secondary analysis is to investigate the factors that affect adherence in a telephone-based intervention to reduce secondhand smoke exposure to children among a low-income population of women.

**Methods:** Of those enrolled in the KiSS study, 163 cases assigned to the intervention group were used in these secondary analyses. After reviewing the literature, 15 variables of interest were identified as potentially having an association with adherence. A Lasso regression was used to select out variables that were insignificant or “unimportant” to predicting the outcome variable, total missed phone sessions. The remaining variables were then used in a Poisson regression to determine if there was any significant correlation with the outcome.

**Results:** Of the 15 variables in the Lasso regression, six variables were found to potentially have an association with total missed phone sessions. These six variables include: education level, total household occupants, total household smokers, life stress score, program support score, and smoking self-efficacy score. The Poisson regression determined that three of these variables did have a significant correlation with missed

phone sessions. Lower education level, greater program support, and smoking cessation self-efficacy related to greater number of missed phone sessions.

**Conclusion:** Those with higher education may complete more phone sessions because they may be more familiar with the importance of not exposing their children to secondhand smoke. Greater reported program support may be related to more missed phone sessions because the participant may feel that they received the support they needed from one or two of the phone sessions and no longer needed to participate.

Another reason for this relationship could be that because the participant felt so supported by the phone session counselor, if they had exposed their child to secondhand smoke, their motivation to please would hinder their adherence. Another analysis would be needed in order to confirm this hypothesis. Lastly, the participants confidence in refraining from smoking may have lead them to miss more phone sessions because they felt that they already had the tools to refrain from exposing their children to secondhand smoke exposure.

This analysis confirms that there are many barriers involved in good adherence and that adherence is influenced by many factors. There is a lack of conclusive data about what affects adherence in the current literature. If research could identify what improves or impedes adherence behaviors, the effectiveness of any treatment could be maximized.

This thesis is dedicated to my mom, Sue. Your unwavering support has been the primary source of my motivation to push through the challenges of graduate school and in life in general. Thank you for being a fantastic mother, lifelong teacher, role model, and best friend; and showing me what true strength and dedication looks like. Thank you to my wife, Alicia, for absorbing the role of “household 6” during this chaotic time of our lives and for standing by me through all joys and challenges of graduate school. Thank you to my sister, Shannon, and my brother, Kevin, for being my life mentors. Your support and senses of humor has allowed me to keep moving forward throughout this program. Lastly, thank you to Grace, for all the pep talks and encouragement, you are family. I Love you all more than anything in the world.

## ACKNOWLEDGMENTS

I would like to thank Dr. Donna Coffman for her mentorship this past year. The completion of this paper, and of my degree, would not be possible without your guidance. I am forever grateful for your support, advocacy, and knowledge. My thanks also extend to Dr. Bradley Collins and Dr. Stephen Lepore for not only being a part of my thesis committee but allowing me to utilize their data for this research. In addition, I would like to thank Xizhen Cai for her help running analyses and Melissa Godfrey for her help navigating the data.

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## **1. LITERATURE REVIEW**

### **What is Adherence?**

Adherence is a key, yet complicated aspect of research that can make or break strides in public health interventions. Adherence is defined as the “active, voluntary, and collaborative involvement of the patient in a mutually acceptable course of behavior to produce a therapeutic result” (Meichenbaum & Turk, 1987). This infers that there is an agreement between a patient and a provider to work towards a health goal through some sort of treatment or intervention. Much of what we know about adherence comes from a pharmaceutical perspective that focuses on prescribed medication interventions. Throughout this review, adherence is referring to the adherence of an intervention or treatment.

### **Medication Adherence**

Medication adherence focuses solely on whether patients are taking their medications as prescribed by a doctor, including how frequently and how long. Medication adherence has been a growing issue and concern to doctors and healthcare providers because of evidence that shows how prevalent nonadherence is, as well as how expensive and risky it is for adverse health outcomes (Ho, Bryson, & Rumsfeld, 2009). Over the last few decades, as many as 40% of patients are nonadherent to treatment recommendations depending on the complexity of the suggested regimen (Martin et al., 2005). However, when treatment requires lifestyle changes, such as altering existing

habits and creating new ones, failure to adhere can be up to 70%. When clinicians begin recommending behavioral interventions for illness prevention and intervention, adherence falls appreciably when it affects a patient's lifestyle (Martin et al, 2005).

### **Behavioral Intervention Adherence**

A report by the World Health Organization suggests low adherence rates to long-term chronic disease treatments and interventions are a worldwide problem and are even more prevalent in developing countries (Sabate, 2003). In addition, as the burden of chronic disease increases, so does the impact of low behavioral adherence. This impact includes exorbitant health care costs. If adherence can be improved, so can the safety of patients as well as the effectiveness of health care interventions. Adherence to any regimen or intervention reflects many types of behavior whether it be seeking medical attention, filling prescriptions, taking medication as prescribed, getting vaccinations, and attending follow-up appointments. In addition, adherence could also reflect behavior changes that look to modify personal hygiene, self-management of diabetes or asthma, smoking, contraception, risky sexual behaviors, unhealthy diets, or poor physical activity (Sabate, 2003). According to the Institute of Medicine Committee on Health and Behavior (2001), human behavior is a main component in the maintenance of good health and in preventing diseases. In addition, evidence suggests that effective programs to change behavior for health requires a multifaceted approach to help people learn new behaviors, change those behaviors, and maintain new behaviors (Institute of Medicine, 2001). The National Institutes of Health explains that adherence is a mediator of the effectiveness of treatments and of public health as a whole (Institute of Medicine, 2001). There are many factors that affect adherence to an intervention, whether it is clear

communication about the intervention, difficulty of the intervention, or other factors such as access and cost of intervention.

### **Why is Adherence Important?**

Good adherence can have many public health and economic benefits. Good adherence to any intervention is a main indicator of the effectiveness of the treatment. Poor adherence hinders the clinical benefit of interventions while good adherence maximizes any benefit of treatment or programming (Sabate, 2003). Good adherence is exceptionally beneficial for promoting healthy behaviors such as diet modification, increased exercise, smoking cessation, and healthy sexual behaviors. Good adherence has shown substantial effects in reducing blood pressure, managing type 2 diabetes, and managing chronic depression. There is significant evidence that suggests that self-management programs for those with chronic diseases substantially improves health status while reducing utilization cost. These types of programs show a reduction in the number of patients who are hospitalized, length of stay, and outpatient visit frequency. Data suggests a savings ratio of 1:10 in some cases (Sabate, 2003).

### **What Affects Adherence?**

Before adherence can be improved, it is important to understand why nonadherence happens. Since adherence relies on individuals' behaviors, it is imperative to consider demographic factors, psychological factors, and social factors in order to understand completely how these factors may interact with adherence rates (Delamater, 2006). In addition, considering health care providers, medical and insurance systems, and disease and treatment factors is also important.

## **Demographic Factors**

Demographic factors including socioeconomic status, ethnicity, gender, and education level have been associated with lower behavioral adherence regarding diabetes treatment and colorectal screening. Lower education level and lower health literacy have been shown to affect adherence levels negatively (Delamater, 2006). Although there is plenty of data that include sociodemographic factors in the research, there are competing conclusions about which sociodemographic factors actually play a role and to what degree.

### **Age**

Age has been reviewed as a potential factor that can affect adherence. In one study, age is grouped into three categories. The breakdown is as follows: elderly (aged 55 and older), middle (40 to 54 years of age), and young (under 40 years old) (Fang et al., 2017). This study concludes that the elderly may have better adherence rates than the other two age groups. Middle-aged patients were less likely to be adherent to therapies. Young adult populations also have a tendency to have poorer adherence as well. This may be because young and middle-aged populations may be busier and therefore do not have as much free time to wait for clinic appointments or treatments. Another possibility is that younger adult populations may not be able to afford healthcare as comfortably as older adults or may not feel their health is as much of a priority (Fang et al., 2017).

### **Race**

Ethnicity is another demographic factor that has been studied for adherence. Studies show that Caucasians generally show the highest adherence rates compared to Hispanic and African-American populations. However, this may be due to other factors

such as socio-economic status and possible language barriers. Therefore, these confounding variables may account for the relationship between ethnicity and adherence (Rolnick, 2013).

### **Gender**

Gender has been examined as a predictor of adherence in many studies. There is no conclusive evidence about gender as a predictor. Some studies suggest that women are better adherers while other studies suggest that males are better. One thing that these studies agree on however, is that gender is not a highly relevant predictor (Rolnick, 2013).

### **Educational Level**

Educational level seems to be another sociodemographic variable that has not been found to have a large impact on adherence rates. Most studies that look at education level report slightly better adherence rates among those that are more educated. One study shows that even those who are very educated may not fully understand their condition or believe in the benefits of adhering to their therapy or regimen. However, in terms of smoking cessation adherence, what is known about education level shows that those who are more educated had a higher probability of smoking cessation than those who had less education. More specifically, those who had a post-secondary degree had a much greater chance of cessation than those with a high school diploma or less (Fernandez, 2006).

### **Marital Status**

Marital status has been shown to influence adherence positively in many studies. It is speculated that this positive influence is due to support and help from the spouse (Rolnick, 2013).

### **Demographics and Nonadherence**

Few studies have been able to identify who is more likely to be adherent based solely on characteristics. One study that looked at non-adherence in at-risk heart failure patients found that non-adherent patients compared to adherent patients tended to more likely be men, African-American, younger, less likely to have diabetes, and more likely to use illicit drugs. In addition, adherent patients were less likely to smoke and more likely to have comorbidities. Lower health literacy and higher amounts of prescriptions were associated with misunderstanding of instructions which is associated with nonadherence and hospital visits for heart failure. Having to change routine was also an indicator of nonadherence in this population (Lee et al., 2015).

Another study that looked at adherence in a large Midwest population 18 years of age and older, found that those who were living in a higher socioeconomic status and were white were more likely to be adherent. Those who were living in the lowest quartiles of education, poverty, and income had lower adherence. The youngest participants aged 18-48 had the lowest rates of adherence and men had higher adherence rates than women (Rolnick et al, 2013).

Among HIV positive populations in Nigeria, women tend to report missing their drugs as prescribed almost twice as frequently as men. More than half of participants contributed this nonadherence to forgetfulness (Okoronko, 2013). Women also reported

poor communication by providers and side effects of drugs as reasons for nonadherence. The age group of 20-29 reported the most nonadherence. Those who were not married were more non-adherent. This could be an indication that support can help increase adherence. In this same population, employed participants reported higher nonadherence, attributing it to forgetfulness and busy schedules (Okoronko, 2013). Clearly this is a much different population than the study about heart failure. Because of cultural differences among populations it can be hard to generalize findings about adherence among all people and populations, which is another barrier when predicting nonadherence. Results from different studies come to different conclusions and more research is required to address these differences. There is also little to no data about personality differences in adherence rates.

### **Stress Factors**

Stress and life events are also factors that may contribute to how well a patient may adhere to an intervention. High levels of stress as well as maladaptive coping may be negatively associated with adherence. Among youth and adults, anxiety, depression, and eating disorders have been linked with worse diabetes management and adherence (Institute of Medicine, 2001).

Although there is research on adherence and life events among HIV patients, there is a lack of research regarding other types of interventions. Among HIV patients, greater perceived life stress and number of major life stressors is correlated to poorer adherence among HIV-infected individuals (Leserman et al., 2008). These are stressors such as a death in a family, experiencing poverty, or losing a job. It is known that increase in stress is related to poorer adherence and a greater likelihood of depression and

other mental health issues. This is a multifaceted variable in that its effect on adherence could be influenced by coping style, type of life stress, and support (Bottonari, 2010).

### **Support and Adherence**

Robert Weiss proposed a theory about social relations in 1974 that described six functions that can be acquired through social relationships (Bottonari, 2010). This includes attachment or emotional support, social integration or network support, reassurance of work or self-esteem support, reliable alliance or tangible aid, guidance or information support, and opportunity for nurturance which can increase one's self-worth. Weiss suggested that these six social functions are needed to adequately cope with stress. Having a strong support system, like peers, friends, or family to help provide these provisions can ultimately lead to successful behaviors in programs such as exercise adherence and behavioral change (Bottonari, 2010). Many studies have already linked the association of social support to healthy outcomes and health behaviors.

One common regimen that is affected substantially by social support is exercise adherence. As much as 50% of people will be nonadherent to their physical activity regimen by month six of their program (Duncan & McAuley, 1993). In terms of exercise, social support in forms of spousal participation, exercise buddies, encouraging physical activity leaders, and fellow participants have been shown to substantially increase adherence. In addition, poorer exercise adherence has been linked to those who participate in exercise programs individually compared to those who partake in some sort of group physical activities daily or weekly (Duncan & McAuley, 1993). In another study of those who are affected by coronary heart disease (CHD), nonadherence to healthy behavior regimens was just as likely as among those who did not have CHD. When

measuring “social capital” or the extent of which one participates in social behaviors such as networking, trusting others, sense of belonging, and social support, those who had a stronger sense of social capital showed significantly better adherence to physical activity and good nutrition than those who did not (Fang et al, 2017).

How health care providers interact with patients plays a key role in adherence and health outcomes among these patients. Health care professionals are tasked with prescribing regimens and interventions, interpreting it to the patient, monitoring, and providing feedback. It is important to recognize the positive relationship between the provider communication style and adherence rates. Using “positive talk” and using language that is understandable for patients greatly increases rates of adherence to behavioral interventions. Follow ups and continuity of care are essential to continue good adherence behaviors. Patients who see themselves as partners in a prescribed regimen have better health outcomes and warmth and empathy are imperative to successful communication, adherence, and positive health outcomes (Sabate, 2003).

### **Trust and Patient-Provider Relationship**

The historical legacy of maltreatment in the United States of African Americans in healthcare has led to distrust in the community regarding health care providers. We know that this mistrust continues throughout generations and has been influential in the low enrollment rate of African Americans in medical research as well as barriers to seeking healthcare. In a study looking at African American women with hypertension and medical adherence, women who trusted their health care providers were significantly more likely to be adherent with their medications compared to those who did not trust

their provider (Abel & Efirid, 2013). This finding is consistent with other research that looked at adherence rates in the African American community.

Even though the historic significance of the Tuskegee study may be the first that comes to mind when thinking about distrust in healthcare, there may be distrust towards healthcare providers regardless of race, gender, socioeconomic and minority status. Trust is essential to emotional disclosure and is extremely important in patient-physician relationships. Patients must be convinced that their physician is their advocate and can understand their unique experience in being a patient. They need to believe that their physician is providing them with reliable and honest information. Physicians that promote trust, who communicate effectively, and are compassionate are more successful in fostering cooperation and adherence with medical recommendations. Rates of adherence have been found to be as much as three times higher in physician relationships with very high levels of trust and knowledge of the patient as a whole. Patients' trust in their physician exceeds many variables when reporting satisfaction levels in care (Martin et al., 2005).

### **Self-Efficacy**

Self-efficacy is defined as “an individual’s belief in his or her capacity to execute behaviors necessary to produce specific performance attainments” (Duncan & McAuley, 1993). Self-efficacy also reflects confidence in the ability to have control over one’s own motivation, behavior, and social environment. The Self-Efficacy Theory presented by Bandura (1977), describes that people generally will only attempt something they think they can accomplish and will not attempt anything they do not think they can accomplish. Those that have a high sense of self-efficacy will attempt more challenging tasks. Those

that doubt their ability to accomplish hard tasks will generally avoid them and see these tasks as threatening. Previously mastered experiences, vicarious experiences of previous successes or failures related to the current end goal behavior, verbal persuasion, and physiological state affects one's self-efficacy and the end goal behavior.

Self-efficacy is associated with higher levels of adherence as well as greater perceived social support (Martin et al., 2005). Self-efficacy is oftentimes included in models regarding behavioral change and is thought to be essential in any type of adherence. Self-efficacy refers to the internal belief that a person has the ability to successfully carry out a behavior in order to produce an outcome. In other terms, a person believes that they are capable of carrying out a task. People tend to be more motivated if they believe that they are able to complete a task. Self-efficacy can influence a person on various levels: cognitive, motivational, and affective. Adherence to treatment has been positively linked to self-efficacy. There are several factors that could potentially affect self-efficacy levels such as depression, social support, and anxiety (Martin et al., 2005).

### **Depression**

Depression is the most prevalent mental illness and a major cause of functional limitations. Depression is often diagnosed along with an anxiety disorder. These types of psychological disorders are also often comorbid with chronic illnesses. This can increase morbidity and mortality. In one meta-analysis, findings suggested that depression is one of the strongest predictors of patient nonadherence. The risk of nonadherence is 27% higher among patients who are depressed than those who are not. Patients with depression experience issues such as pessimism, cognitive impairment, and withdrawal

from social support. All of these can reduce the willingness to follow any type of treatment regimen (Martin et al, 2005).

### **How Can We Improve Adherence?**

It is apparent that adherence improvement involves a multifaceted program that takes into account many factors spanning from support to clinician relationship. When looking at medication adherence, approximately 33% of people will be adherent when given a prescription whereas approximately 15-25% will not be adherent despite any type of intervention. Intervention programs are designed to target that middle 50% of individuals who may possibly become adherent if given the proper tools. Interventions used to improve adherence are divided into three groups. These include patient interventions, health professional interventions, and health delivery changes. This is true for both medication and behavioral adherence interventions (Maningat et al., 2013). Some interventions are multifaceted and include combinations of these three types of interventions. Although more effective, they are more labor intensive and expensive.

The mnemonic “SIMPLE” is used to explain the different ways to enhance patient adherence (Atreja et al., 2005). These intervention categories include simplifying regimen characteristics, imparting knowledge, modifying patient beliefs, patient communication, leaving behind bias, and evaluating adherence. The simplification of already existing interventions is one major way to increase adherence among patients. This could include reducing dosage to once a day rather than twice or behavioral simplification such as receiving a phone call for follow up rather than going back to the physician office (Atreja et al., 2005).

Imparting knowledge means getting the patient to understand better their condition and treatment regimen. Patients often do not understand how a prescription works, how to properly do exercises, or how exactly a regimen is effective and helping their condition. Healthcare providers can provide better patient education by limiting instructions to 3 or 4 major points, using simple language, giving oral teaching in conjunction with written materials, involving loved ones, and reinforcing what is taught (Atreja et al., 2005).

Modifying patients' beliefs is important because human behavior is often contingent on beliefs, intentions, and self-efficacy. In order to facilitate behavior change, healthcare providers need to ensure that patients see themselves as at-risk individuals. They must believe that their medical condition is serious and needs treatment, the proposed treatment results in positive effects, have their perceived barriers of treatment addressed, and have the confidence to perform healthy behavior regimens. The most promising advance in adherence has been the introduction of health monitoring through text messaging and technology. It is necessary that the provider tailor the interventions to suit the needs of each patient (Atreja et al., 2005).

Patient-physician communication and interpretability is very important for adherence. As many as 50% of patients do not fully understand what they have been told once they have left the office. On average, physicians interrupt patients about 18 seconds into the description of their current health concerns (Atreja et al., 2005). There needs to be trust between patient and health care provider. Often, social support can play a significant role in communication with providers and understanding of interventions. "Leaving bias" refers to health care providers dropping their personal biases about patient

demographics and behaviors. Patients also have their own preconceived biases and need to come to appointments with open minds and be willing to listen and ask questions. These biases and addressing nonadherence go hand in hand, in that doctors greatly underestimate patient nonadherence and it is imperative that it is understood in order to correct it. If a provider has no way of detecting nonadherence, it is not possible to correct it. By simply conducting self-report surveys, providers can at least have an idea of what adherence looks like on an individual level and it can be addressed on a case by case basis (Atreja et al., 2005).

### **Technology and Adherence**

The addition of technology such as phones, applications, email, and text messaging in interventions to increase adherence have shown varying results. The growth of technology has led to an increase in mobile health management. The use of text messages and mobile phone applications have been shown to improve adherence among adolescents with chronic health conditions (Badawy et al., 2017).

A review of texting and mobile apps for the improvement of adherence to preventive behaviors in adolescents showed varying results (Badawy et al., 2017). In terms of clinic attendance, there was no significant difference in clinic attendance resulting from text reminders. However, in a study of mental health clinic attendance, there was a significant improvement in the texting intervention group. For effects on contraception, it was reported that there was a significantly higher continuation rate at six months in the texting intervention group, but not beyond 6 months. They concluded that the intervention only helped for short-term adherence. As for effects on risky behavior, there was no evidence of significant improvement on risky behavior knowledge, condom

use at last sexual intercourse, or proportion of condom use over the past 28 days. These results were also the same for alcohol consumption. For text message-based interventions on smoking cessation, there was a significant reduction in cigarette consumption at 6 months among all participants and a significant increase in the number of quit attempts among occasional smokers. There was no significant improvement in 7-day or 4-week smoking abstinence. Texting interventions had significant improvements in oral hygiene with lower average gingival index scores at 6-months, 9-months, and one year. In addition, the intervention group had lower plaque index scores and visible white spots during those same time measures (Badawy et al., 2017).

Text interventions and mobile app interventions have varying results in physical activity adherence. An intervention for people with musculoskeletal conditions found that there was better home exercise adherence among those who used apps with remote support compared to those who received paper handouts (Lambert et al., 2015). In another study among older adults in Urban Malaysia, texts promoting exercise resulted in significantly more exercise among the intervention group although it was not maintained after texts stopped (Muller et al., 2016). A meta-analysis that looked at randomized controlled trials of the effect of phone interventions on weight loss among obese adults showed a significant decrease in body weight (about 1.44 kg or 3 lbs.) and an average BMI reduction of 0.24 units. The association of mobile phone intervention and weight loss did not differ by type of phone intervention. However, there was no association between intervention and waist circumference (Lui et al., 2015). Many studies show that interventions are significantly effective in short term adherence but tend to not be significant in the long-term.

Using mobile reminders for vaccine adherence is another emerging intervention in public health. Vaccine series completion using a text reminder adherence approach showed significantly higher results for second and third dose HPV vaccines. Another study that used a smartphone app to improve immunization in children in rural China showed that the intervention group who used the app had higher full vaccination coverage than the control group. Doctors in this study found it to be easier and time-saving to manage child vaccination information because the vaccination information was readily available in the app (Rolnick et al., 2013). In another randomized clinical trial, adolescents with chronic medical conditions who are at risk of vaccine-preventable infection received text message reminders, some embedded with educational information and some with only the reminders. Those who received only the reminder messages missed significantly less vaccinations than both the control and educational embedded messages (Birkhauer et al., 2017).

In many ways, technology has been used to positively affect behavioral and medication adherence. It is apparent that it significantly affects short-term adherence in many facets of public health. More research is needed to analyze long-term effects and effects on interventions aimed at behavioral change.

### **Barriers to Adherence in Technology Based Interventions**

Although the idea of using technology to improve health seems ideal, there are various issues and barriers that may affect technology-based interventions. Plenty of research suggests the benefits of cellphone use in various types of interventions. Cell phones increase the mobility of communication and allow the availability of information immediately. In low-income populations, the use of technology can help with safety

whether it be phoning emergency services in dangerous situations or accessing healthcare for those with chronic conditions. There is also speculation that cellphones may be especially important for low income populations. In order to get the security and assurance benefits of cellphones, individuals must first have a cellphone. Low income cellphone users often experience disruptions in cellphone access. This could be because the cellphone is shared or the ongoing cost of having a cellphone may be burdensome.

### **Smoking Cessation, Adherence & Technology**

Adherence to smoking cessation programs is important to see a reduction in tobacco use. In a community-based smoking cessation program, the highest rate of attendance occurred during the first three weeks after target quit date. In addition, the use of daily patches was highest in those first weeks. After the first three weeks, there was poorer adherence to counseling sessions and patch use. The total number of weeks that the participants were abstinent had a positive association with counseling adherence. There was also a positive association with patch adherence, however it was a weaker association (Reid et al., 2008).

High rates of technology use among young adults and easier accessibility makes online or phone interventions ideal for this population. Phone-based interventions for smoking cessation that consisted short text messages that would guide a person through the process of behavior change have been more commonly used. A text messaging intervention for smoking cessation showed that those who were randomized to a program that sent regular text messages which provided smoking cessation advise, support, and distraction were more likely to quit at six weeks into the program than those who were randomized to the control group (Rodgers, 2005). This was consistent among groups

defined by age, sex, income level, and geographic location. All participants received a full month of text messaging to control for possible nuisance factors that may affect phone discontinuation (Rodgers, 2005).

A newer approach to the use of phones in smoking cessation is the use of mobile phone applications (“apps”). Oftentimes the use of these apps is prompted by the smoker themselves. Over 47 apps as of 2009 have been identified that encourage and support smoking cessation (Abroms et al., 2011). Some of these apps track health benefits and dollars saved since quitting, some utilize calendars to track days until or post quit date, and some use hypnosis techniques to distract from smoking. Other apps use a ration method that “allows” one to smoke at a certain frequency. On average, only two of eight smoking cessation exercises or modules are completed before discontinuing the use of the app or online program (Abroms et al., 2011). However, as many as 50% of users found a cessation app a useful means of support to quit smoking (Chevalking et al., 2018). Some studies show that when given the option, about 60% of participants will utilize the mobile apps (Chevalking et al., 2018).

One online study suggests that financial incentives contribute to better adherence rates among young adults in smoking cessation interventions (An et al., 2006). When targeting this population, modeling the web-based platform as a college-life magazine rather than a stop-smoking webpage increased initial participation. Adding peer support and creating an easy-to-navigate webpage that directs users through educational activities also helped keep users engaged for a longer duration of time (An et al., 2006). Although these findings target young adult populations, it is important to note that this could be indicative on how to engage and retain participants across other intervention platforms. If

the intervention is explicitly displaying a direct message about changing negative behaviors, it may deter users who may be more open to a softer message about behavior change combined with other relevant content.

## **Conclusion**

Adherence is a frequently discussed topic in public health right now. It is a complicated and multidimensional issue that is incredibly difficult to solve. As many as 40-70% of patients are non-adherent depending on the type of regimen prescribed, how complicated the regimen is, and how much the patient has to alter their lifestyle (Sabate, 2003). There are many other factors that may affect adherence such as socioeconomic status, how much a patient trusts their provider, and accessibility. The issue of nonadherence may never fully be eradicated, but if it can be managed, we may see a much healthier population with fewer chronic illnesses, less money wasted in healthcare, and more effective treatment regimens.

Technology can be beneficial in terms of short-term adherence but there still is not enough support for the long-term effects of technological reminders for program or medication adherence. With the rise of technology use over the past few decades, it seems that using cell phones for text or call reminders or even apps would be a natural transition in working towards better adherence in this generation. It is imperative that more research is done to further the knowledge of the technological impact on adherence.

The purpose of this cross sectional, secondary analysis is to investigate how various factors, such as coping skills, support, stress, and beliefs, affect adherence to a telephone-based intervention to reduce second-hand smoke exposure in children among

low socioeconomic status mothers. The present study will assess how this external reason for reducing second-hand smoke may affect adherence to an intervention.

Secondhand smoke is smoke from burning tobacco products, including cigarettes, cigars, or pipes. Since 1964, approximately 2.5 million nonsmokers have died from health issues caused by exposure to secondhand smoking. Especially in children, secondhand smoke can cause the following issues: ear infections, asthma attacks, respiratory symptoms, and greater risk of sudden infant death syndrome (Center for Disease Control and Prevention, 2017). Between 2011 and 2012, 40% of all children, and 70% of black children ages 3-11 were exposed to secondhand smoke regularly in the United States (Center for Disease Control and Prevention, 2017). Parental smoking is the number one source of secondhand smoke exposure in children (Lepore et al., 2013).

This literature review suggests various factors that may affect adherence to a behavioral intervention for reducing secondhand smoke exposure to children. The following analysis of the Kids Safe and Smoke Free (KiSS) trial examines how marital status, education level, depression score, life stress score, household demographics, self-efficacy, and perceived personal and program support affect participant adherence to the individual behavioral counseling portion of the KiSS intervention, specifically, the number of completed phone sessions.

## 2. METHODS

### Study Background

The data were collected by researchers at Temple University for a two-group randomized controlled trial aimed to reduce secondhand smoke exposure in children. The Kids Safe and Smoke free (KiSS) trial tested the efficacy of a multi-level behavioral intervention approach to reduce parental smoking and child smoke exposure. The two groups were comprised of a standard clinic intervention and attention control group. The experimental intervention included a pediatric clinic-level intervention, individual behavioral counseling, and community services for nicotine dependence. The attention control group included an individual telephone health and nutrition education.

Data were collected over three measurement periods including pre-intervention, 3 months end of treatment, and 12-month long-term follow up. Participants were recruited through urban pediatric healthcare clinics. The primary outcome measure was child's secondhand smoke exposure and the secondary outcome was parent smoking abstinence. The study design was guided by the Consolidated Standards of Reporting Trials (CONSORT) criteria and approved by the Institutional Review Board (IRB) (Temple University protocol number 20045) (Lepore et al., 2013).

The pediatric clinics included in the KiSS study service mostly low-income, racial and ethnic minority populations. There were five inclusion criteria, including having received the pediatric clinic-level intervention, English-speaking, 18 years or older in age, ability to report daily smoking, and having a child in the home under age 11 that is exposed to cigarettes in the car or home daily. The exclusion criteria included psychiatric

disturbance reported by patient, currently pregnant, or three or more alcoholic beverages per day (Lepore et al., 2013).

The procedures for the KiSS study included training the providers in the partnering pediatric clinics to give concise guidance about child secondhand smoke exposure and referring these parents to the KiSS research staff. These staff confirmed eligibility criteria for the participants and collected the self-reported data at baseline, end-of-treatment, and follow up through telephone interviews. These interviewers were blinded to the group in which the participants were assigned to. The participants were randomized into the groups, experimental and attention, stratified by race and site. Participants received their treatment group allocation during their home visit orientation and provided urine samples for collection.

Before randomization, all participants, in both the intervention and control group, received the clinic level intervention related to child secondhand smoke exposure, as recommended by the American Academy of Pediatrics. Once randomization occurred, the participants were grouped to either receive individual level intervention related to smoking and secondhand smoke exposure or education about nutrition on a budget (Lepore et al., 2013).

This intervention stressed the three elements, “Ask, Advise, and Refer” (AAR): ask about the child’s secondhand smoke exposure, advise about the risks of secondhand smoke, and refer to cessation programs in the community (Lepore et al., 2013). This AAR model allowed advice from a credible healthcare provider to be offered by phone to minimize the barriers of traveling to a clinic. This method focused on the safety of the child first and then encouraged smoking cessation in the later sessions. The KiSS study

design and procedures were based on a review of smoking cessation interventions in medical practices that concluded that cessation success is related to the number and duration of reinforcing sessions by personnel who communicate the same advice. For example, a doctor and a health counselor who both communicate about smoking cessation and secondhand smoke exposure to a person thereby creating reinforcing “doses” of advice (Lepore et al., 2013).

Before phone counseling sessions began, a home visit was made to provide an orientation to the intervention. This behavioral counseling took place over a 12-week period. Counselors helped to guide participants to re-structure their efforts in smoking behavior change into smaller and more manageable steps. This helped to maintain motivation by setting short-term goals and building confidence in achieving their long-term goals. In addition, the counselors educated and informed participants of resources for smoking cessation and provided solutions to barriers of adherence to cessation medication (Lepore et al., 2013).

The KiSS clinic level component was modeled after Clinical Effort Against Secondhand Smoke Exposure (CEASE), but the KiSS intervention was integrated with each clinic’s electronic health record system. The four main goals of the KiSS study were to identify parents who smoke in the child’s home, counsel smokers about establishing no smoking policies around children, help parents with smoking intervention and medication services, and record information in the electronic health record to keep ongoing records of secondhand smoke exposure (Lepore et al., 2013).

For the KiSS study, the primary outcome variable was secondhand smoke exposure in the child. The child cotinine level was measured through urine levels at

baseline and 12-month follow up. Child secondhand smoke exposure was also measured by parental report of the number of cigarettes that the child was exposed to during the 7 days prior to all assessments. The secondary dependent variable was parents smoking cessation, which was self-reported at 3 and 12-month assessments, and cotinine-verified at the 12-month assessment. The KiSS trial results demonstrated efficacy of the KiSS intervention in promoting exposure reduction to children as well as parents' quit success (Collins et al., 2018).

## **Secondary Analysis**

### **Variables**

The dependent variable is whether the participant completed any phone sessions, and if so the total number of phone sessions completed. The first variable is Completed Any Phone Sessions where 0 = "No" and 1 = "Yes". This variable indicates if the participant did not complete any phone sessions. The second variable is Total Number of Phone Sessions. This variable was transformed to represent total missed phone sessions. So rather than predicting how many were completed, we will analyze how many were not completed. This transformed variable can then be modeled using a Poisson distribution and represents non-adherence. Since this study is looking at what affects non-adherence to a phone counseling intervention among low income, minority women to reduce secondhand smoke exposure to children, factors from several different categories are included in the regression analyses to determine the most important variables.

Sociodemographic variables include education level and marital status. These variables were recorded at baseline. The education variable asked how far the adult participant had gotten to in school. The 5 categories included: some high school or less,

high school graduate or GED, vocational school or some college, college degree, and above college degree such as professional or graduate degree. The marital status variable asked whether the adult was currently married or living with a partner. Those who answered “no” were coded as 1 and those who answered “yes” were coded as 2 (Lepore et al., 2013).

Psychosocial factors include smoking cessation self-efficacy, smoke free home and car self-efficacy, perceived personal and program support, depressive symptoms, life stress inventory, and social constraint. Smoking cessation self-efficacy was recorded at end of treatment. Subjects were asked to rate their degree of certainty that they could resist smoking in 12 specific situations involving various levels of stress. The response format was 1= not at all sure, 2= a little sure, 3=somewhat sure, 4= very sure. This scale was summed to create a final self-efficacy score. This sum of all responses, is used in this analysis as a measure of smoking cessation self-efficacy (DiClemente, 1981).

Smoke-free home and car self-efficacy is an adaption of DiClemente’s (1981) smoking self-efficacy measure, in which subjects are asked to rate how sure they are that they can create and keep a smoke-free home and car. This variable is calculated as a total score of the responses to three items, which are 1= not at all sure, 2= a little sure, 3= somewhat sure, and 4= very sure. This measure was recorded at end of treatment.

The Adapted Partner Interaction Questionnaire- Personal Support assessed support provided by a partner or other close adult for smoking reduction or cessation (Lepore et al., 2013). This questionnaire inquired if a close adult would encourage good smoking avoidance behaviors and to what degree. This 12- question scale included questions for both negative and positive behaviors and was scored by calculating a ratio

between those two types of behaviors. This variable used a response scale of never, rarely, sometimes, and often, and was recorded at the 12-month follow up.

The Adapted Partner Interaction Questionnaire-Program Support was an adaptation of the previous Adapted Partner Questionnaire for Personal Support and was used to assess the level of support provided by the phone counselor. This included how encouraging the phone counselor was in advocating for healthier behaviors from the adult concerning their smoking habits. This scale did not have items about negative behaviors so the final variable was calculated by adding the responses to 11 items together. The higher the total sum score, the more support the participant received from the counselor. The response format was never, rarely, sometimes, and often and was assessed at the 12-month follow up (Roski, 1996).

Other variables included in this analysis were household structure and smokers, preference for condition, and Fagerstrom Test for Nicotine Dependence, all assessed at baseline. The household structure and smokers variable is an inventory of who currently resides in the home as well as their age, their relationship to the participant, and smoking status. This variable indicated if the other household residents were parents, spouses, significant others, adult children, other family members, non-relatives, or minor children. If one of the residents was a current smoker, he or she would be included in the household smokers variable. All of these household residents were included in the Household Total residents variable. The household residents were summed for the final variable. Preference for condition asked if the participant preferred to either be in the smoking condition, nutrition condition, okay with either condition, or did not indicate a preference. Fagerstrom Test for Nicotine Dependence is a self-report of nicotine

dependence. This variable ranges from 0 to 10 and is the sum of 6 questions (Fagerstrom, 2011; Heatherton et al., 1991).

### **Missing Data**

Missing data is common in most studies and may arise for many reasons and most particularly, in this case, survey nonresponse, which is common when there are a large number of survey items. Incomplete data can arise from refusal, attrition, or lack of understanding of a question and it is imperative that these missing data are addressed (Little & Rubin, 2002). The respondents who have missing data may follow similar patterns but differ significantly from those with complete data. Omitting them from the analysis altogether may not be a valid solution. There must not be a systemic relationship between the missing values and the observed data. If there is a systemic relationship then the data are missing not at random (MNAR). Running a complete case analysis may lead to biased results if these data are not missing completely at random (MCAR). Little's test (Little & Rubin, 2002) will be run to test if the data are MCAR. If the p-value for Little's test is not significant then the data are assumed to be MCAR, and if the p-value is significant, then the MCAR assumption is rejected.

Given rejection of the MCAR assumption using Little's test and assuming that the data are missing at random (MAR), multiple imputation (MI) will be used to create "complete" datasets by filling in values for any missing data. Each imputed dataset will be analyzed as if it were a complete data set and the results are combined by averaging over the multiple imputed datasets.

## **Data Analysis**

The analysis in this study will determine which variables have an impact on total missed phone sessions. Identifying these variables will be done through a Lasso regression (James et al., 2013). Then, a Poisson regression analysis will be used to estimate and test the effects of the identified variables.

### **Lasso Regression**

Lasso regression will be used to identify the most important predictors of missed phone sessions. The Lasso- least absolute shrinkage and selection operation- is a regression analysis method that conducts variable selection by shrinking the coefficient estimates towards zero. The Lasso technique will be used to enforce sparsity in the number of variables by forcing some of the regression coefficients to be exactly zero. This sparsity is what makes the Lasso a successful variable selection tool in regression analysis. Since there is no limitation on the number of variables in the analysis, then many variables can be used to ensure that we select the most important variables in predicting non-adherence. In the final model, the outcome variable will only be related to a few of the predictor variables, which will be those with coefficients that are not estimated to be zero. The Lasso uses an  $L1$  penalty rather than an  $L2$  penalty. The  $L1$  penalty is unique in that it uses an absolute value error whereas the  $L2$  uses the mean square error. The advantage with the absolute value error is that it reduces the coefficients down to zero and therefore, will allow for even more sparsity in the model. The Lasso can be fit to any type of outcome variable such as binary, continuous, or count. In this case, a Poisson distribution will be used.

## **Poisson Regression**

After the Lasso regression identifies which variables are unimportant, a Poisson regression will be utilized to obtain the estimates and significant tests (p-values) for the variables identified as important in the Lasso. A Poisson regression will be conducted because there are not any significant tests included in the Lasso regression. Poisson regression is a generalized linear model used to model count data. These values are quantified with discrete, non-negative, whole numbers in a fixed interval. Data are characterized with a Poisson distribution when the observations are count variables, events are independent of one another, and the interval of time are the same for each participant and known (Hayat, 2013). This technique is referred to as a generalized linear model which is similar to a linear regression. Poisson regression assumes that the response variable has a Poisson distribution and assumes that the logarithm of its value is able to be modeled by a linear combination of parameters. Other generalized linear models are not specific to count data and would not be adequate for this type of analysis.

After running an analysis, models are often assessed for how well the model fits the data. Since maximum likelihood estimation is used in Poisson regression, different statistical tests are used to look at goodness of fit, specifically the deviance. Typically, smaller deviance values indicate a model with a better fit (Hayat, 2013). R-squared is the typical measure in linear regression to quantify how much of the dependent variable is explained by the predictors. In Poisson regression and other general linear models, a pseudo-R is used instead.

### 3. RESULTS

There was a total of 327 cases in the original study, but only the individuals assigned to the intervention group were included, which was a total of 163 individuals. The dependent variable, total phone sessions was modified to represent the total number of phone sessions that were missed. Table 1 shows the breakdown of the categorical variables. Single participants comprised 56.4% of the sample and 43.6% of the participants were married or living with a partner. Participants that had some high school experience or less encompassed 26.4% of the sample while 68.4% were high school graduates or had some vocational or college experience. The sample was 4.9% college graduates. 28.8% of the sample had significant others who smoked. Most of the participants did not indicate a preference for condition. Table 2 shows the mean and standard deviations of the continuous variables. Figure 1 shows a graphical representation of the total missed phone sessions. Two participants missed no phone sessions. Sixty-four participants only missed one phone session. Twenty-nine participants missed two phone sessions. Sixteen participants missed half of the phone sessions. Fourteen missed four phone sessions and 22 participants missed five phone sessions. Sixteen participants missed all of the phone sessions.

<b>TABLE 1. DESCRIPTIVE STATISTICS FOR CATEGORICAL VARIABLES</b>			
<b>VARIABLE</b>	<b>Category</b>	<b># of Participants</b>	<b>Percentage</b>
MARITAL STATUS	Single	92	56.4%
	Married/Living with Partner	71	43.6%
EDUCATION	Some HS or Less	43	26.4%
	HS Graduate/GED	61	37.4%
	Vocational School/Some College	50	30.7%
	College Degree	8	4.9%
	Professional/Graduate Degree	1	0.6%
SIGNIFICANT OTHER SMOKES	No	116	71.2%
	Yes	47	28.8%
PREFERENCE FOR CONDITION	Prefers Smoking Condition	15	9.2%
	Prefers Nutrition Condition	0	0.0%
	Okay with Either	11	6.7%
	Did Not Indicate a Preference	108	66.3%
TOTAL PHONE SESSIONS MISSED	0	2	1.2%
	1	64	39.3%
	2	29	17.8%
	3	16	9.8%
	4	14	8.6%
	5	22	13.5%
	6	16	9.8%

<b>TABLE 2. DESCRIPTIVE STATISTICS FOR CONTINUOUS VARIABLES</b>					
VARIABLE	Mean	Standard Deviation	Minimum	Maximum	Range
DEPRESSION SCORE	10.77	6.59	0	29	29
FAGERSTROM TEST FOR NICOTINE DEPENDENCE	4.16	1.97	0	9	9
LIFE STRESS SCORE	8.22	5.50	0	26	26
NUMBER OF PEOPLE LESS THAN 18 IN HOUSEHOLD	2.58	1.40	1	8	7
PERSONAL SUPPORT SCORE	25.76	9.34	10	40	30
PROGRAM SUPPORT SCORE	40.15	5.40	11	44	33
SOCIAL CONSTRAINT SCORE	33.79	11.43	15	57	42
SMOKE-FREE HOME SELF-EFFICACY SCORE	10.35	1.79	4	12	8
SMOKING SELF-EFFICACY SCORE	31.30	10.53	12	48	36
TOTAL HOUSEHOLD OCCUPANTS	4.52	1.63	2	9	7
TOTAL HOUSEHOLD SMOKERS	1.60	0.76	1	4	3

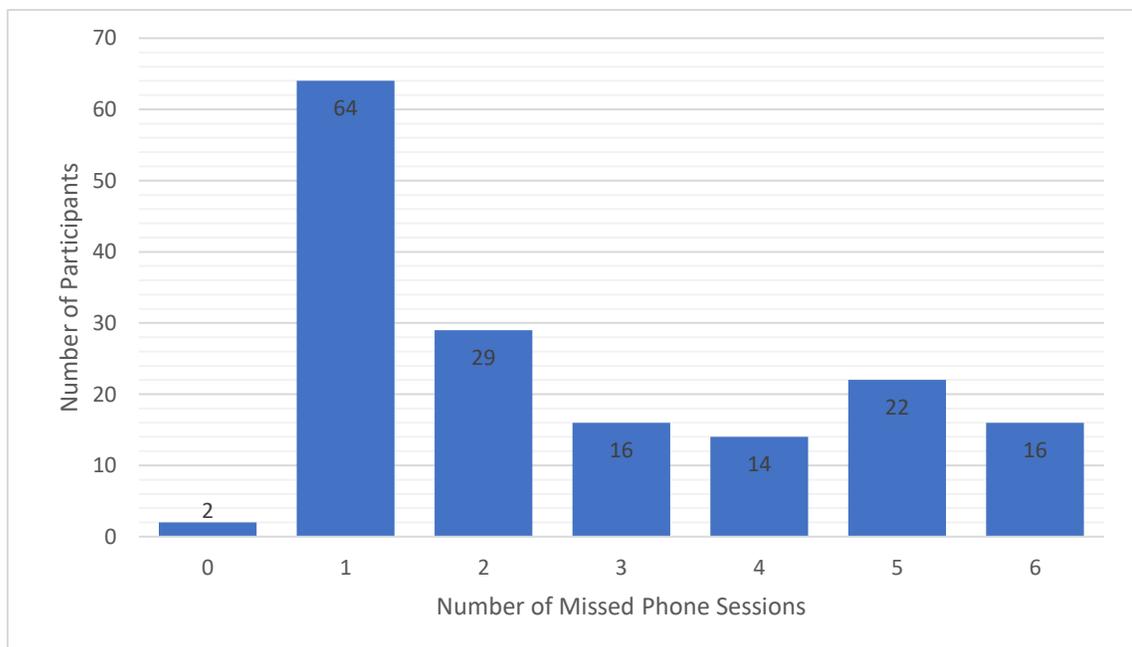


Figure 1. Total Missed Phone Sessions (n=163)

## Missing Data

Eight of the 15 independent variables had cases with missing data. There were no cases with missing dependent variable values. Smoking cessation self-efficacy had a total of 21 missing values, social constraint 32 missing values, life stress score 32 missing values, condition preference 29 missing values, Adapted Partner Interaction Questionnaire Program Support 28 missing values, Adapted Partner Interaction Questionnaire Personal Support 30 missing values, smoke-free home self-efficacy score 21 missing values, and the ratio of Adapted Partner Interaction Questionnaire 21 missing values. Little's Test for Missing Completely at Random (MCAR) was run. The missing values were not MCAR ( $\chi^2(122) = 151.95, p = .03$ ). Since the data were not MCAR, multiple imputation was used by chained equations utilizing the R package *mice* to handle the missing data with the number of multiple imputations equal to  $m=5$ . Since there are no established rules for combining results across imputations when using the Lasso, we used only one of the imputed data sets.

## Lasso Regression

With a complete imputed data set, a Lasso regression analysis was conducted using the GLMNET package in R to further identify which variables to include in the final Poisson regression. Lambda, the tuning parameter in the penalty term, was chosen based on 10-fold cross-validation. Figure 2 shows the cross-validation Poisson deviance as a function of log lambda. The cross-validation grid shows cross-validated error curve including a one standard deviation band. The top of the plot is annotated with the size of the model. The left vertical line represents the minimum error and the right vertical line represents the largest value of lambda within one standard error of the minimum. Table 3

shows the coefficients for lambda where the cross-validation deviance is at the minimum and for the lambda of the sparsest (i.e., simplest) model within one standard error of the minimum cross-validation deviance. There were no variables that had a coefficient of zero in the minimum lambda column. However, using the sparsest model within one standard error of the minimum lambda, results in 9 of the 15 variables having coefficients of exactly zero (see Figure 3) and six that do not. The “one-standard-error” rule is used to select the best model because it acknowledges that risk curves are estimated with error. This rule errs on the side of parsimony. This sparse model suggests that marital status, Fagerstrom Test for Nicotine Dependence, depression score, whether or not the significant other smoked, total number of residents under the age of 18 in the household, social constraint score, preference for condition, smoke-free home self-efficacy score, and personal support score had a coefficient of zero and therefore were deemed unimportant. The remaining 6 variables were included in the Poisson regression.

In Figure 3, each of the 15 variables are represented by a different line. As the norm of the vector of coefficients is smaller, many of the coefficients are close to zero or zero. As the norm increases, some of the coefficients deviate from zero. This model shows how six of the coefficients do deviate from zero and should be included in the model and the others do not and should not be included in the model.

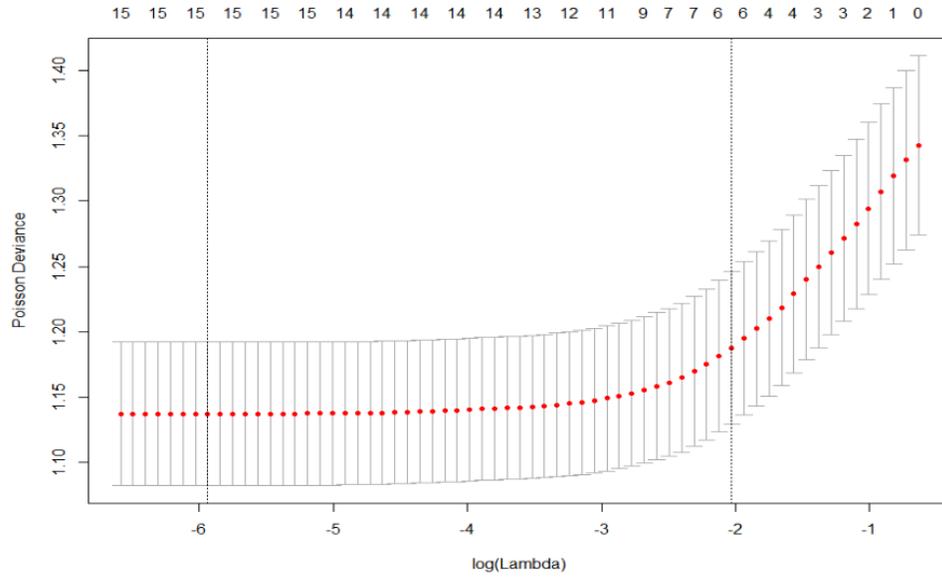


Figure 2. Cross-Validation Deviance as a Function of Lambda Grid

<b>Table 3. Cross-Validation Fit Matrix</b>		
Variable	<b>Lambda.min</b>	<b>Lambda.se</b>
<b>(Intercept)</b>	0.094	0.311
<b>Marital Status</b>	-0.081	—
<b>Education</b>	-0.132	-0.065
<b>Fagerstrom Test for Nicotine Dependence</b>	-0.001	—
<b>Depression Score</b>	-0.002	—
<b>Life Stress Score</b>	0.019	0.007
<b>Number of People Less than 18 in Household</b>	0.047	—
<b>Personal Support Score</b>	0.001	—
<b>Preference for Condition</b>	-0.038	—
<b>Program Support Score</b>	0.027	0.017
<b>Significant Other Smokes</b>	-0.093	—
<b>Social Constraint Score</b>	-0.003	—
<b>Smoke-Free Home Self-Efficacy Score</b>	0.011	—
<b>Smoking Self-Efficacy Score</b>	0.011	0.010
<b>Total Household Occupants</b>	-0.086	-0.089
<b>Total Household Smokers</b>	0.171	0.011

“ — ” indicates that the variable was not significant

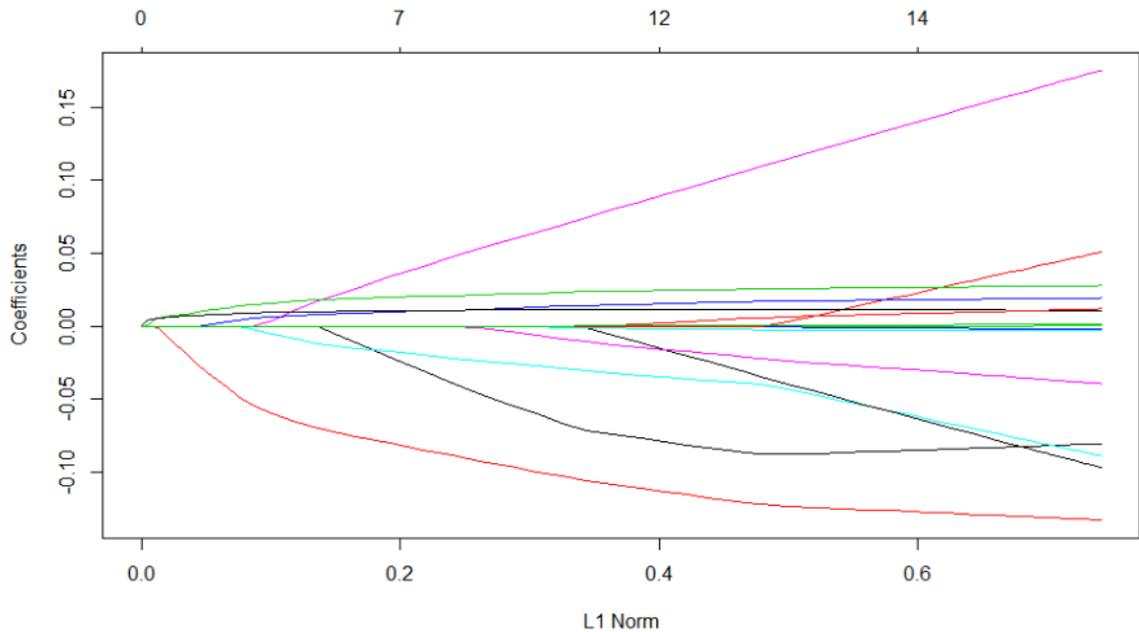


Figure 3. Cross-Validation Coefficients Against L1 Norm

### Poisson Regression

After identifying which variables should be used in the Poisson regression through the Lasso analysis, education, total household occupants, total household smokers, life stress score, program support score, and smoking cessation self-efficacy score were included in the regression. Of the six variables included in the Poisson regression, only three variables were statistically significant at an alpha level of 0.05. The estimates and standard errors are shown in Table 4 and the confidence intervals are given in Table 5. Education had an estimate of -0.113 ( $p = 0.022$ ). As education level increased, the number of phone sessions missed decreased. Smoking cessation self-efficacy score had an estimate of 0.011 ( $p = 0.014$ ). As smoking self-efficacy score increased, the number of phone sessions missed increased. Lastly, program support score had an estimate of 0.033 ( $p = 0.002$ ). The higher the program support score, the more phone

sessions that were missed. Total household occupants, total household smokers, and life stress score were not statistically significant at  $p > .05$ . The pseudo R-square value was 0.14. This was calculated by using McFadden's pseudo R-square:  $1 - (\text{residual deviance}/\text{null deviance})$ . The null deviance was 218.9 and the residual deviance was 188.3. The pseudo R-square indicates how much of the variance in the outcome is explained by the model.

Variable	Estimate	Standard Error	Z-Value	Pr (> z )	Significance
<b>(Intercept)</b>	-0.264	0.475	-0.557	0.578	
<b>Education</b>	-0.113	0.049	-2.285	0.022	*
<b>Total Household Occupants</b>	-0.043	0.028	-1.540	0.124	
<b>Total Household Smokers</b>	0.086	0.059	1.469	0.142	
<b>Life Stress Score</b>	0.013	0.008	1.609	0.107	
<b>Program Support Score</b>	0.033	0.011	3.080	0.002	**
<b>Smoking Self-Efficacy Score</b>	0.011	0.004	2.455	0.014	*
* Denotes Significance at $p < .05$					
** Denotes Significance at $p < .01$					

Degrees of Freedom= 162  
 Null Deviance: 218.9  
 Residual Deviance: 188.3  
 Pseudo R-Squared: .14

Variable	2.50%	97.50%
<b>(Intercept)</b>	-1.231	0.633
<b>Education</b>	-0.211	-0.017
<b>Total Household Occupants</b>	-0.099	0.011
<b>Total Household Smokers</b>	-0.030	0.201
<b>Life Stress Score</b>	-0.003	0.028
<b>Program Support Score</b>	0.013	0.054
<b>Smoking Self-Efficacy Score</b>	0.002	0.019

#### 4. DISCUSSION

In a sample of women who were enrolled in a phone intervention to reduce secondhand smoke exposure to children, smoking cessation self-efficacy score, education level, and program support score were the only significant predictors of adherence in this population. Since this study was exploratory in nature, hypothesis of how these variables would influence adherence rates was not conducted.

As smoking cessation self-efficacy score increased, so did the number of missed phone sessions. This could be because those who feel that they have the ability and tools to resist the urge to smoke in many situations may not feel that they need the intervention or phone counselor in order to be successful. It is possible that they felt that since they can successfully avoid an urge to smoke in these situations, they do not need to participate in the phone sessions. This association between smoking cessation self-efficacy and adherence is not what previous literature has reported. Typically, higher self-efficacy results in better adherence and intervention outcomes (Martin et al., 2005).

As the level of education increased, the number of phone sessions that were missed decreased. This makes sense in that those who were more educated tended to miss less phone sessions. People who have had more education are likely more aware of the impact that secondhand smoke exposure has on children and the negative effects. Those that have a higher level of education are likely to be more motivated to reduce smoke exposure to their children. This finding is consistent with other research about adherence and education levels. This supports findings in previous research that suggests that more educated individuals are more likely to have better adherence rates and better smoking cessation rates.

As the program support score increased, so did the number of missed phone sessions. Since the first sessions focused on the protection of the child and then shifted focus to longer term goals and eventually cessation, it is possible that the participant may have felt that they did not want to answer the phone if they had exposed the child to secondhand smoke early on. In other words, the motivation to please would have an opposing effect on adherence to phone sessions. This motivation to please could be an effect modifier and would benefit from further analysis.

The program support questionnaire asked whether or not the phone counselor went over substitutes for smoking, encouragement for nicotine replacement, confidence for a smoke free home, and helpful tips for keeping children away from tobacco smoke. This finding is not consistent with existing research on program support and adherence. Typically, the more program support or the better the relationship with the counselor, the more adherent the individual may be, especially among exercise interventions (Duncan & McAuley, 1993). It is imperative to note, however, that it was not known in this analysis which phone sessions were missed and why. It is possible that phone service may have been interrupted due to broken phones, service disruptions, or the phone was shared since the population consisted of mostly low-income women. Additionally, there could have been a false sense of support among those who missed more sessions if the phone counselor reached out using other methods such as text or email regarding missed sessions.

### **Strengths**

There are several strengths to this study. Since there is not a lot of conclusive research about what affects adherence, this study adds to what is already known. This

study had a strong adherence and retention rate compared to other studies among the low-income and predominantly minority women population. The population of this study is another strength, contributing more information to low-income populations. Additionally, this study is unique in that most of the existing research looks at adherence to program protocols for smoking cessation whereas this study investigated what affects adherence to an intervention to reduce secondhand smoke exposure.

### **Limitations**

There are a few limitations to this study. The cross-sectional nature of this analysis makes it difficult to establish any causal relationship between variables. Looking at the smoking cessation self-efficacy association with adherence, it is unknown if the participants felt that they were confident enough without a phone session or if the phone session made them feel more confident about their abilities to resist smoking. This study also did not include details about the exact phone counselor protocol for each phone session. For example, if there was no answer or the service was disconnected and if the counselor contacted the participants through text or mail. Including this in the analysis would have given insight about whether the participant dropped out or was nonadherent.

Another limitation is that much of this data is self-reported, which by nature, leads to variability in the interpretation of questions and data. Since this data exclusively looks at women who are in a low-income bracket and minority status, results may not be generalizable. These participants were also recruited in a pediatric doctors' offices and were not seeking a smoking cessation program. In addition, the Poisson regression had a low pseudo R-squared value meaning that a lot of the variability is not explained by the model. There are many factors that could have affected adherence in this population in

general, including access to consistent phone service and other technological barriers to a phone-based intervention.

## **Conclusion**

This study adds to the growing body of research regarding adherence. There is not a lot of conclusive research about what affects adherence in most populations. There are plenty of data and research on the adherence rates to smoking cessation interventions following protocols, however, there is not much looking at adherence to smoking cessation interventions or interventions to reduce secondhand smoke exposure to children. Smoking cessation can be a very difficult task, but to reduce secondhand smoke exposure can be incredibly important to the health of our younger generations. One in three nonsmokers who live in rental housing are exposed to secondhand smoke. Secondhand smoke can cause serious health issues in children and adults alike. The more that is known about adherence to interventions for reduction in secondhand smoke exposure, or any medical intervention for that matter, the more likely better health outcomes and better population health overall. Good medication and behavioral adherence is vital for good health outcomes and increasing good population health. It is clear that there is a long way to go before completely understanding how adherence works and how to improve it among all populations and interventions.

## REFERENCES

- Abel, W. & Efirid, J. (2013). The association between trust in health care providers and medication adherence among black women with hypertension. *Frontiers in Public Health, 1*, 66.
- Abroms, L., Padmanabhan N., Thaweethai, L., & Phillips, T. (2011). iPhone apps for smoking cessation: a content analysis. *American Journal of Preventive Medicine, 40*, 3.
- Adler, A., Martin, N., Mariani, J., Tajer, C., Owolabi, O., Free, C., Serrano, N., Casas, J., Perel, P. (2017). Mobile phone text messaging to improve medication adherence in secondary prevention of cardiovascular disease. *The Cochrane Database of Systematic Reviews, 21*, 12-17.
- An, L., Perry, C., Lein, E., Klatt, C., Farley, D., Bliss, R., Ehlinger, E. (2006). Strategies for increasing adherence to an online smoking cessation intervention for college students. *Nicotine & Tobacco Research, 8*(1), 7-12.
- Atreja, A., Bellam, N., & Levy, S. R. (2005). Strategies to enhance patient adherence: making it simple. *Medscape General Medicine, 7*, 4.
- Badawy, S., Barrera, L., Sinno, MG., Kaviany, S., O'Dwyer, LC., Kuhns, L. (2017). Text messaging and mobile phone apps as interventions to improve adherence in adolescents with chronic health conditions: a systematic review. *JMIR Mhealth Uhealth, 5*, 66.
- Birkhäuer, J., Gaab, J., Kossowsky, J., Hasler, S., Krummenacher, P., Werner, C., & Gerger, H. (2017). Trust in the health care professional and health outcome: a meta-analysis. *PLoS ONE, 12*, 2. <https://doi.org/10.1371/journal.pone.0170988>
- Bottonari, K. A., Safren, S. A., McQuaid, J. R., Hsiao, C.-B., & Roberts, J. E. (2010). A longitudinal investigation of the impact of life stress on HIV treatment adherence. *Journal of Behavioral Medicine, 33*, 486-495. <http://doi.org/10.1007/s10865-010-9273-9>
- Brendryen, H., & Kraft, P. (2008). Happy ending: a randomized controlled trial of a digital multi-media smoking cessation intervention. *Addiction, 103*(3), 478-484. doi:10.1111/j.1360-0443.2007.02119.x
- Centers for Disease Control and Prevention (2017). Smoking & Tobacco Use. Retrieved March 28, 2018, from [https://www.cdc.gov/tobacco/data\\_statistics/fact\\_sheets/secondhand\\_smoke/general\\_facts/index.htm](https://www.cdc.gov/tobacco/data_statistics/fact_sheets/secondhand_smoke/general_facts/index.htm)
- Chen, L., Du, X., Zhang, L., van Velthoven, M. H., Wu, Q., Yang, R., & Koepsell, J. C. (2016). Effectiveness of a smartphone app on improving immunization of

- children in rural Sichuan Province, China: a cluster randomized controlled trial. *BMC Public Health*, 16, 909.
- Chevalking, S. L., Allouch, S. B., Brusse-Keizer, M., Postel, M. G., & Pieterse, M. E. (2018). Identification of users for a smoking cessation mobile app: quantitative study. *Journal of Medical Internet Research*, 20(4).
- Cohen, S. & Lichtenstein, E. (1990). Partner behaviors that support quitting smoking. *Journal of Consulting and Clinical Psychology*, 58, 304-309.
- Collins, B.N., Nair, U.S., Godfrey, M., Winickoff, J.P., Moughan, B., Bryant-Stephens, T., Taylor, D., Fleece, D., Davey, A., & Lepore, S.J. (2018). An office-initiated multilevel intervention for tobacco smoke exposure: A randomized trial. *Pediatrics*, 141, Supplement 1, S75-86. PMC5745677.
- Cugelman, B., Thelwall, M., & Dawes, P. (2011). Online interventions for social marketing health behavior change campaigns: a meta-analysis of psychological architectures and adherence factors. *Journal of Medical Internet Research*, 13, 17. <http://doi.org/10.2196/jmir.1367>
- Delamater, A. M. (2006). Improving patient adherence. *Clinical Diabetes*, 24, 71. <https://doi.org/10.2337/diaclin.24.2.71>
- DiClemente, C.C. (1981). Self-efficacy and smoking cessation maintenance; A preliminary report. *Cognitive Therapy and Research*, 5(2), 175-187.
- Duncan, T. E., & McAuley, E. (1993). Social support and efficacy cognitions in exercise adherence: a latent growth curve analysis. *Journal of Behavioral Medicine*, 16, 199–218. <https://doi.org/10.1007/BF00844893>
- Fang, J., Wang, W., Li, J., Li, H., & Shao, C. (2017). The correlates of social capital and adherence to healthy lifestyle in patients with coronary heart disease. *Patient Preference and Adherence*, 11, 1701–1707. <http://doi.org.libproxy.temple.edu/10.2147/PPA.S140787>
- Fernández, E., Schiaffino, A., Borrell, C., Benach, J., Ariza, C., Ramon, J. M., & Kunst, A. (2006). Social class, education, and smoking cessation: long-term follow-up of patients treated at a smoking cessation unit. *Nicotine & Tobacco Research*, 8, 29-36. doi:10.1080/14622200500264432
- Fagerstrom, K. (2011). Determinants of tobacco use and renaming the FTND to the Fagerstrom Test for Cigarette Dependence. *Nicotine and Tobacco Research*, 14(1), 75-78. Doi:10.1093/ntrntr137
- Hayat, M.J., Eckardt, P., Higgins, M., Kim, M., & Schmiede, S. (2013). Teaching statistics to nursing students: An expert panel consensus. *Journal of Nursing Education*, 52, 330 - 334. <https://doi.org/10.3928/01484834-20130430-01>

- Heatherton, T., Kozlowski, L., Frecker, R., & Fagerstrom, K. (1991) The Fagerstrom test for nicotine dependence: a revision of the Fagerstrom tolerance questionnaire. *British Journal of Addiction*, 86, 1119-1127.
- Ho, P. M., Bryson, C. L., & Rumsfeld, J. S. (2009). Medication adherence: its importance in cardiovascular outcomes. *Circulation*, 119, 3028–3035.  
<https://doi.org/10.1161/CIRCULATIONAHA.108.768986>
- Hofstetter, A., Barrett, A., Camargo, S., Rosenthal, S., & Stockwell, M. (2017). Text message reminders for vaccination of adolescents with chronic medical conditions: A randomized clinical trial. *Vaccine*, 35, 4554-4560.
- Institute of Medicine (US) Committee on Health and Behavior: Research, Practice, and Policy. (2001) *Health and behavior: The interplay of biological, behavioral, and societal influences*. Washington (DC): National Academies Press.
- Iuga, A. O., & McGuire, M. J. (2014). Adherence and health care costs. *Risk Management and Healthcare Policy*, 7, 35–44.  
<http://doi.org/10.2147/RMHP.S19801>
- James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). *Introduction to Statistical Learning with Applications in R*. New York: Springer.
- Kampshoff, C. S., Jansen, F., van Mechelen, W., May, A. M., Brug, J., Chinapaw, M. J., & Buffart, L. M. (2014). Determinants of exercise adherence and maintenance among cancer survivors: a systematic review. *The International Journal of Behavioral Nutrition and Physical Activity*, 11, 80.
- Krstajic, D., Buturovic, L. J., Leahy, D. E., & Thomas, S. (2014). Cross-validation pitfalls when selecting and assessing regression and classification models. *Journal of Cheminformatics*, 6, 10. <http://doi.org/10.1186/1758-2946-6-10>
- Lambert, T., Harvey, L., Avdalis, C., Chen, L., Jeyalingam, S., Pratt, C., & Lucas, B. (2015). An app with remote support achieves better adherence to home exercise programs than paper handouts in people with musculoskeletal conditions: A randomised trial. *Journal of Physiotherapy*, 63, 161-167.
- Lee, D., Mansi, I., Bhushan, S., Parish, R., (2015). Non-adherence in at-risk heart failure patients: characteristics and outcomes. *Journal of Nature and Science*, 1, 95.
- Lepore, S. J., Winickoff, J. P., Moughan, B., Bryant-Stephens, T. C., Taylor, D. R., Fleece, D., & Collins, B. N. (2013). Kids Safe and Smokefree (KiSS): A randomized controlled trial of a multilevel intervention to reduce secondhand tobacco smoke exposure in children. *BMC Public Health*, 13(1).  
[doi:10.1186/1471-2458-13-792](https://doi.org/10.1186/1471-2458-13-792)

- Leserman, J., Ironson, G., O’Cleirigh, C., Fordiani, J. M., & Balbin, E. (2008). Stressful life events and adherence in HIV. *AIDS Patient Care and STDs*, 22(5), 403–411. <http://doi.org/10.1089/apc.2007.0175>
- Li, S. (2008). Factors affecting therapeutic compliance: A review from the patient’s perspective. *Therapeutics and Clinical Risk Management*, 4, 269–286. doi:10.2147/tcrm.s1458
- Little, R. J. A., & Rubin, D. B. (2002). *Statistical Analysis with Missing Data* (2nd ed.). Hoboken, NJ: Wiley.
- Liu, F., Kong, X., Cao, J., Chen, S., Li, C., Huang, J., & Kelly, T. N. (2015). Mobile phone intervention and weight loss among overweight and obese adults: A meta-analysis of randomized controlled trials. *American Journal of Epidemiology*, 181, 337–348.
- Maningat, P., Gordon, B. R., & Breslow, J. L. (2013). How do we improve patient compliance and adherence to long-term statin therapy? *Current Atherosclerosis Reports*, 15, 291. <http://doi.org/10.1007/s11883-012-0291-7>
- Martin, L. R. (2009). *Health behavior change and treatment adherence: Evidence-based guidelines for improving healthcare*. New York: Oxford University Press.
- Martin, L. R., Williams, S. L., Haskard, K. B., & DiMatteo, M. R. (2005). The challenge of patient adherence. *Therapeutics and Clinical Risk Management*, 1, 189–199
- Mbuagbaw, L., Mursleen, S., Lytvyn, L., Smieja, M., Dolovich, L., & Thabane, L. (2015). Mobile phone text messaging interventions for HIV and other chronic diseases: an overview of systematic reviews and framework for evidence transfer. *BMC Health Services Research*, 1533. doi:10.1186/s12913-014-0654-6
- Meichenbaum, D., & Turk, D. C. (1987). *Facilitating treatment adherence: A practitioner’s guidebook*. New York: Plenum Press.
- Müller, A. M., Khoo, S., & Morris, T. (2016). Text messaging for exercise promotion in older adults from an upper-middle-income country: randomized controlled trial. *Journal of Medical Internet Research*, 18, 5.
- Okoronkwo, I., Okeke, U., Chinweuba, A., & Iheanacho, P. (2013). Nonadherence factors and sociodemographic characteristics of HIV-infected adults receiving antiretroviral therapy in Nnamdi Azikiwe University Teaching Hospital, Nnewi, Nigeria. *ISRN AIDS*, Article ID 843794, 8. doi:10.1155/2013/843794
- Petrella, R. J., Stuckey, M. I., Shapiro, S., & Gill, D. P. (2014). Mobile health, exercise and metabolic risk: a randomized controlled trial. *BMC Public Health*, 14, 1082.
- Pomerleau, C., Carton, S., Lutzke, M., Flessland, K. & Pomerleau, O. (1994). Reliability of the Fagerstrom test for nicotine dependence. *Addictive Behaviors*, 19, 33–39.

- Sabaté, E. (2003). *Adherence to long-term therapies: evidence for action*. Geneva: World health organization.
- Reid, Malcolm S. (2008). Smoking cessation treatment in community-based substance abuse rehabilitation programs. *Journal of Substance Abuse Treatment*, 35,68–77.
- Rodgers, A. (2005). Do u smoke after txt? Results of a randomised trial of smoking cessation using mobile phone text messaging. *Tobacco Control*, 14(4), 255-261. doi:10.1136/tc.2005.011577
- Rolnick, S. J., Pawloski, P. A., Hedblom, B. D., Asche, S. E., & Bruzek, R. J. (2013). Patient characteristics associated with medication adherence. *Clinical Medicine & Research*, 11, 54–65. <http://doi.org/10.3121/cmr.2013.1113>
- Roski, J., Schmid, L. & Lando, H., (1996). Long-term associations of helpful and harmful spousal behaviors with smoking cessation. *Addictive Behaviors*, 21, 173-185.
- Wheeler, D. C., Czarnota, J., & Jones, R. M. (2017). Estimating an area-level socioeconomic status index and its association with colonoscopy screening adherence. *Plos One*, 12(6). doi:10.1371/journal.pone.0179272
- Zhang, J. X., Crowe, J. M., & Meltzer, D. O. (2017). The differential rates in cost-related non-adherence to medical care by gender in the US adult population. *Journal of Medical Economics*, 20, 752-759. doi:10.1080/13696998.2017.1326383