

## ABSTRACT

Title of dissertation: THE INFLUENCE OF WATERPIPE LOUNGE MENU LABELING ON INTENTION TO QUIT SMOKING AND PERCEIVED HARM, RISK AND ADDICTION AMONG YOUNG ADULT WATERPIPE TOBACCO SMOKERS IN THE UNITED STATES

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In the US, young adults 18 to 24 years of age have experienced the most notable decline in smoking rates from 24.4% in 2005 (Mariolis et al., 2006) to 7.8% in 2018 (Creamer, 2019). However, alternative tobacco products, such as waterpipes (also known as hookahs), are increasingly becoming the first product used by tobacco-naïve young adults and may be a gateway to nicotine addiction (Meier, Tackett, Miller, Grant, & Wagener, 2015). Tobacco surveillance measures show that among young adults in the US, 44.3% reported ever use (lifetime) and 10.7% current use (every day and someday) of waterpipe tobacco (Kasza et al., 2017). Although public health best practices for communicating the harms of tobacco use are well-established in traditional products, such as cigarettes, there is a critical knowledge gap on how to properly communicate the harms of waterpipe tobacco smoking (WTS) to current and potential consumers. In this dissertation, two independent studies were conducted to examine the effect of health-related information on waterpipe lounge menus on intention to quit smoking, as well as perceived relative harm, perceived risk of health consequences and perceived relative addiction.

Study 1, a population-based survey experiment, recruited participants (n = 213) from Amazon Mechanical Turk, a crowdsourcing online marketplace. Participants were randomized to one of four menu groups using a two-by-two experimental design with ‘health warning message’ and ‘nicotine content’ as factors. Participants that viewed waterpipe lounge menus with a health warning had greater perceived risk of decreased lung function from WTS, those that viewed waterpipe lounge menus with nicotine content had greater perceived risk of heart attack from

WTS, and those that viewed a waterpipe lounge menu with health-related information (health warning message + nicotine content) had greater perceptions of harm from WTS. There were no significant differences between groups on intention to quit smoking or perceived relative addiction.

Study 2, a laboratory-based virtual reality experiment, recruited participants (n = 96) from a large, metropolitan university. Participants were randomized to one of two experimental: (1) Experimental condition viewing a waterpipe lounge with health-related information (health warning message + nicotine content); (2) Control condition viewing a plain waterpipe lounge menu. Participants that viewed a waterpipe lounge menu with health-related information reported significantly greater intention to quit smoking, as well as greater perceived risk of decreased lung function from WTS compared to those that viewed a plain waterpipe lounge menu. There were no significant differences between groups on perceived relative harm, risk of cancer, risk of a heart attack and relative addiction.

The overall results of Study 1 and Study 2 were consistent with prior research showing that brief health warning messages and nicotine content may increase intention to quit smoking, as well as perceived harm and risk of health consequences (Mays, Tercyak, et al., 2016). In addition, the research expands this evidence by demonstrating that the waterpipe lounge menu is a viable location for delivery of health education messages and product labeling. These findings may be used in future research to design further health communication experiments for WTS, as well as support practice and policy decisions for health warning messages and product labeling specific to waterpipe tobacco.

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## **DEDICATION**

This dissertation is dedicated to my supportive family and friends!

For my husband, Henok, who proclaimed to me on our very first date that he would be a partner to support all my big dreams. He has kept true to his word throughout this journey, and I am forever grateful to have him as my life partner.

For my siblings, Fetsum, Samuel and Tamnnet, who are my loyalist friends and cheerleaders from childhood to adulthood. Our companionship is one of the greatest gifts in life.

For my mother and my father, who are the utmost examples of strength, resilience, humility and unconditional love. I am forever motivated by their journey and sacrifices as immigrant parents. May you be blessed with many healthy and happy years! Edme te'ena ye'habkum!

Finally, for my son, Dagmawi, and my daughter, Ariam, whose arrival into our family motivated me during the long dissertation phase. To be your mother is a gift, honor and joy.

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## **Chapter 1: Introduction**

### **1.1. Background**

Over the past five decades, public health advocates have worked with all levels of government, nonprofit organizations and community groups to reduce tobacco use among adults, prevent initiation among youth and protect non-smokers from exposure to secondhand smoke (U.S. Department of Health and Human Services., 2014). Through a variety of tobacco control efforts, including health education campaigns, smoke-free air policies, increased excise taxes, restrictions on marketing, and improved access to cessation services, the overall cigarette consumption among American adults has declined from 42% in 1965 (U.S. Department of Health and Human Services., 2014) to 13.7% in 2018 (Creamer, 2019). Although this decline in smoking cigarettes is the lowest on record and the transformation in the public perceptions of tobacco smoking is noted as one of the leading public health triumphs, the battle is challenged by the various alternative (or non-cigarette) tobacco products, such as waterpipe, entering the U.S. market (U.S. Department of Health and Human Services., 2014). The Center for Disease Control and Prevention (CDC) reports one out of five adults in the U.S still uses some form of tobacco (U.S. Department of Health and Human Services, 2018). Furthermore, national surveillance data has shown that waterpipe tobacco smoking (WTS) has steadily increased among adults in the U.S., with the highest rates of WTS among adults 18 to 24 years of age (Agaku et al., 2014; Salloum, Thrasher, et al., 2015; Kasza et al., 2017).

WTS is a unique form of tobacco consumption encouraged as less harmful than cigarettes and is increasing the amount of non-daily tobacco users in the U.S. (Blachman-Braun et al., 2014). It is primarily a stationary practice as the waterpipe apparatus is rather large and has several accessories, including a bowl, base, hose, and mouthpiece (Maziak et al., 2004). The smoking sessions can last hours and are a shared social experience with others. The tobacco also

comes in a variety of flavors; thus, appealing to younger consumers (Scott-Sheldon & Stroud, 2018). Misconceptions regarding the health risks of WTS and likelihood of addiction also contribute to the increase in its popularity among youth and young adults. These misconceptions include that WTS is safer than cigarette smoking, that it does not lead to serious disease, and that it does not contain addictive chemicals such as nicotine (Griffiths & Ford, 2013; Heinz et al., 2013; Sterling et al., 2015; Sterling & Nix, 2014). Many misconceptions seem to stem from the belief that the water in the pipe filters the potential harmful chemicals in the smoke (Griffiths & Ford, 2013). However, a growing body of toxicological research shows that WTS is harmful to health of those that are actively and passive exposed to the tobacco smoke. In direct comparisons of WTS with cigarette smoking, WTS was associated with greater carbon monoxide and smoke exposure (Primack, Carroll, Weiss, et al., 2016). Although there is no stated consensus in the research community on where WTS falls on the spectrum of harm for tobacco products, there is agreement from leading scientists, policy makers, academics, and public health advocates across the globe that the product is harmful to overall health of all persons (International Conference on Waterpipe Tobacco Smoking, 2015).

## **1.2. Statement of the Problem**

Young adulthood is a crucial period in life development and a window for engaging in risky behaviors, such as tobacco use (Backinger et al., 2003; Health, 2012; Irwin, 2004; Villanti et al., 2018). These years are associated with more than a twofold increase in the likelihood of initiating cigarette smoking and progressing to regular cigarette smoking in the future (Soneji et al., 2015). Young adults 18 to 24 years of age have experienced the greatest decline in smoking rates from 24.4% in 2005 (Mariolis et al., 2006) to 7.8% in 2018 (Creamer, 2019)—in part

because of to national public education campaigns including “truth” by Truth Initiative and “Tips from Former Smokers” by CDC (Koval, 2016). However, national and state tobacco surveillance reports indicate an emerging trend in new tobacco product use, such as waterpipe, which may offset the decline in cigarette smoking. Alternative tobacco products (ATP), such as the waterpipe, are increasingly becoming the first product used by tobacco-naïve youth and young adults in the United States (Meier et al., 2015). These non-cigarette, tobacco products are growing in popularity among young adults; and rather than seeing less overall tobacco product use in young adults, initiation of tobacco use among these new products is growing (Kasza et al., 2017; Trinidad et al., 2017; Villanti et al., 2017; Watkins et al., 2018).

ATPs emerging in the U.S. now threaten years of anti-tobacco education and policy (Center for Disease Control and Prevention, Office on Smoking and Health, 2015). WTS may be a gateway to nicotine addiction and future tobacco product use. Young adult years are often the period in which non-tobacco users initiate WTS (Fielder et al., 2013; Sidani et al., 2014; Villanti et al., 2015). Flavors play an important role in the initiation and continuation of tobacco product use in young adults (Huang et al., 2017). Research data showed that 83.5% of young adults that are using non-cigarette tobacco products, are using a flavored product, and waterpipe tobacco smokers reported the greatest flavored products use at 85.9% (Bonhomme et al., 2016). Thus, cigarette smoking susceptibility among waterpipe-only smoking youth and young adults is a concern. The 2012-2013 National Adult Tobacco Survey (NATS) data showed that among persons who had never established cigarette smoking, 48% of current waterpipe smokers reported being susceptible to cigarette smoking compared to 16.2% of those who were not current waterpipe smokers (Salloum et al., 2016). This suggests the possibility of a temporal trend between initiation of WTS (or ATPs) and future cigarette smoking.

Tobacco control researchers and regulatory authorities agree that there is a critical knowledge gap on how to properly communicate the health risks and consequences of WTS. However, much of the health communication literature on tobacco products is focused on cigarettes, and it is not clear how effective or adaptable these communication strategies are for other tobacco products (Ross et al., 2017). Tobacco remains a leading risk factor for death and disease in the United States, and there is a plethora of scientific evidence on the associated risks to communicate to the public in support of tobacco prevention and cessation (U.S. Department of Health and Human Services., 2014). Further research is needed to better understand the most effective content and method for communicating the risks and harms of alternative tobacco products, such as waterpipe. This scientific evidence will directly support the mission of the Center for Tobacco Products (CTP) at the U.S. Food and Drug Administration (FDA) to protect public health and reduce tobacco use. Considering the current research landscape and regulatory needs as it pertains to WTS, this dissertation will explore how to effectively communicate accurate information on WTS to young adults (18 to 24 years of age) in the United States using waterpipe lounge menus. There is a need to dispel the misconceptions that WTS is a harmless, non-addictive form of tobacco consumption.

### **1.3. Conceptual Framework (Message Impact Framework)**

For this research, a conceptual model based on the Message Impact Framework (MIF) was developed to examine how health information on waterpipe lounge menus may influence predictors of behavior change in young adults. The MIF was first proposed as a model to explain how pictorial warning messages on cigarette packages could change attitudes and behaviors in smokers (Noar et al., 2017). It was developed from existing communication theory on attention

and cognitive processing (Petty, 2018) as well as health behavior theory on attitudes and beliefs (Ajzen, 1985). Researchers assembled the MIF by reviewing the outcomes variables measured in nearly fifty different longitudinal studies on cigarette warning label studies and organizing these variables into five groups of theoretically-based constructs (attention and recall, warning reactions, attitudes and beliefs, behavioral intentions and perceived effectiveness) (Noar et al., 2017). The MIF suggests that health (warning) messages that draw a viewer's attention and can be recalled after exposure will produce cognitive, emotional or physical reactions (Noar et al., 2017). Strong reactions to health messages will lead to short-term changes in attitudes and beliefs about the behavior, and short-term changes in attitudes and beliefs will lead to behavioral intentions, eventually encouraging a change in the targeted behavior (Noar et al., 2017).

Similarly, the conceptual model (Figure 1) constructed for the studies described in this dissertation suggests that reactions triggered by a warning message and product information on the waterpipe lounge menus may facilitate changes in WTS attitudes and beliefs, as well as intention to quit smoking waterpipe. These reactions may include cognitive processing such as thinking about the harms, risks and addiction of smoking waterpipe tobacco. Consistent with health behavior change theories, such as Theory of Reasoned Action/Theory of Planned Behavior and Health Belief Model, positive attitudes and inaccurate beliefs of the harms and risks of WTS likely are strong motivators for use among young adults (Griffiths & Ford, 2013; Noonan et al., 2011). Thus, factual messages that correct misperceptions about the product characteristics and health consequences of WTS may motivate changes in future decisions to engage in WTS in a lounge environment. Accordingly, the studies identified intention to quit smoking, as well as perceived relative harm, perceived risk of health consequences and perceived relative addiction as key behavioral constructs. Additionally, objective or direct

measures of attention, dwell time and fixation were measured in the virtual reality environment. However, these secondary measures of attention were not included as key constructs in the conceptual model, but selected to provide insight for the direction of future research.

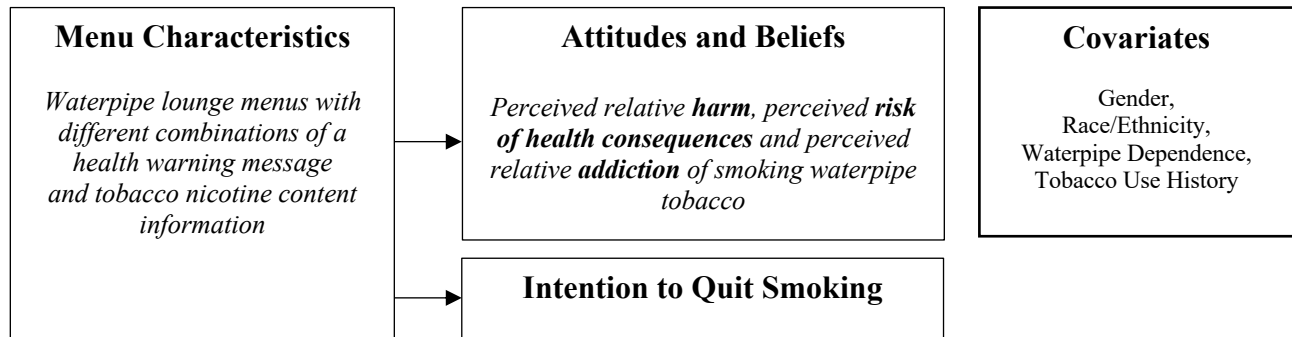


Figure 1. Conceptual Model for Study 1 and 2

#### 1.4. Research Question, Aims and Hypotheses

**Research Question:** How does the content on waterpipe lounge menus effect the intention to quit smoking, as well as the perceived relative harm, perceived risk of health consequences and perceived relative addiction among young adult waterpipe tobacco smokers?

**Aim 1:** Assess the effects of a health warning message and nicotine content on waterpipe lounge menus on intention to quit smoking, as well as the perceptions of relative harm, risk of health consequences and relative addiction among young adult waterpipe tobacco smokers.

To achieve this aim, a factorial experiment (Study 1) was conducted using an online survey panel of young adult waterpipe smokers. The research design and experimental groups are further discussed in Chapter 3 (Methods).

**H1a:** *There was an effect of health information (warning message and nicotine content) presented on waterpipe lounge menus on intention to quit smoking among young adults.*

*Participants that viewed a waterpipe lounge menu with a health warning message and nicotine content (Groups 1) reported greater intention to quit smoking compared to participants that viewed a waterpipe lounge with only a health warning message or nicotine content (Groups 2 and 3) or no health information (Group 4).*

**H1b:** *There was an effect of health information (warning message and nicotine content) presented on waterpipe lounge menus on perceived relative harm of waterpipe tobacco smoking, among young adults. Participants that viewed a waterpipe lounge menu with a health warning message and nicotine content (Groups 1) reported greater perceived relative harm of waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge with only a health warning message or nicotine content (Groups 2 and 3) or no health information (Group 4).*

**H1c:** *There was an effect of health information (warning message and nicotine content) presented on waterpipe lounge menus on perceived risk of cancer from waterpipe tobacco smoking, among young adults. Participants that viewed a waterpipe lounge menu with a health warning message and nicotine content (Groups 1) reported greater perceived risk of cancer from waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge with only a health warning message or nicotine content (Groups 2 and 3) or no health information (Group 4).*

**H1d:** *There was an effect of health information (warning message and nicotine content) presented on waterpipe lounge menus on perceived risk of heart attack from waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu with a health warning message and nicotine content (Groups 1) reported greater perceived risk of heart attack from waterpipe tobacco smoking from waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge with only a health warning message or nicotine content (Groups 2 and 3) or no health information (Group 4).*

**H1e:** *There was an effect of health information (warning message and nicotine content) presented on waterpipe lounge menus on perceived risk of decreased lung function from waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu with a health warning message and nicotine content (Groups 1) reported greater perceived risk of decreased lung function from waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge with only a health warning message or nicotine content (Groups 2 and 3) or no health information (Group 4).*

**H1f:** *There was an effect of health information (warning message and nicotine content) presented on waterpipe lounge menus on perceived relative addiction of waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu with a health warning message and nicotine content (Groups 1) reported greater perceived relative addiction of waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge with only a health warning message or nicotine content (Groups 2 and 3) or no health information (Group 4).*

**H2a:** *There was an effect of a health warning message presented on waterpipe lounge menus on intention to quit smoking, among young adults. Participants that viewed a waterpipe lounge menu with a health warning message (Groups 1 and 2) reported greater intention to quit smoking compared to participants that viewed a waterpipe lounge without a health warning message (Groups 3 and 4).*

**H2b:** *There was an effect of a health warning message presented on waterpipe lounge menus on perceived relative harm of waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu with a health warning message (Groups 1 and 2) reported greater perceived relative harm of waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge without a health warning message (Groups 3 and 4).*

**H2c:** *There was an effect of a health warning message presented on waterpipe lounge menus on perceived risk of cancer from waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu with a health warning message (Groups 1 and 2) reported greater perceived risk of cancer from waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge without a health warning message (Groups 3 and 4).*

**H2d:** *There was an effect of a health warning message presented on waterpipe lounge menus on perceived risk of heart attack from waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu with a health warning message (Groups 1 and 2) reported*

*greater perceived risk of heart attack from waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge without a health warning message (Groups 3 and 4).*

**H2e:** *There was an effect of a health warning message presented on waterpipe lounge menus on perceived risk of decreased lung function from waterpipe tobacco smoking among young adults.*

*Participants that viewed a waterpipe lounge menu with a health warning message (Groups 1 and 2) reported greater perceived risk of decreased lung function from waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge without a health warning message (Groups 3 and 4).*

**H2f:** *There was an effect of a health warning message presented on waterpipe lounge menus on perceived relative addiction of waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu with a health warning message (Groups 1 and 2) reported greater perceived relative addiction of waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge without a health warning message (Groups 3 and 4).*

**H3a:** *There was an effect of nicotine content presented on waterpipe lounge menus on intention to quit smoking, among young adults. Participants that viewed a waterpipe lounge menu with nicotine content (Groups 1 and 3) reported greater intention to quit smoking compared to participants that viewed a waterpipe lounge without nicotine content (Groups 2 and 4).*

**H3b:** *There was an effect of nicotine content presented on waterpipe lounge menus on perceived relative harm of waterpipe tobacco smoking among young adults. Participants that viewed a*

*waterpipe lounge menu with nicotine content (Groups 1 and 3) reported greater perceived relative harm of waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge without nicotine content (Groups 2 and 4).*

**H3c:** *There was an effect of nicotine content presented on waterpipe lounge menus on perceived risk of cancer from waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu with nicotine content (Groups 1 and 3) reported greater perceived risk of cancer from waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge without nicotine content (Groups 2 and 4).*

**H2d:** *There was an effect of nicotine content presented on waterpipe lounge menus on perceived risk of heart attack from waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu with nicotine content (Groups 1 and 3) reported greater perceived risk of heart attack from waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge without nicotine content (Groups 2 and 4).*

**H3e:** *There was an effect of nicotine content presented on waterpipe lounge menus on perceived risk of decreased lung function from waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu with nicotine content (Groups 1 and 3) reported greater perceived risk of decreased lung function from waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge without nicotine content (Groups 2 and 4).*

**H3f:** *There was an effect of nicotine content presented on waterpipe lounge menus on perceived relative addiction of waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu with nicotine content (Groups 1 and 3) reported greater perceived relative addiction of waterpipe tobacco smoking compared to participants that viewed a waterpipe lounge without nicotine content (Groups 2 and 4).*

**Aim 2:** Evaluate the effect of health information on waterpipe lounge menus on intention to quit smoking, as well as the perceptions of relative harm, risk of health consequences and relative addiction through a virtual reality environment.

To achieve this aim, a two-group, laboratory-based experiment (Study 2) was conducted using a university sample of young adult waterpipe smokers. Study 2 also addressed Aims 3 described below. The research design and experimental groups are further discussed in Chapter 3 (Methods).

**H4:** *There is an effect of health information (warning message and nicotine content) on waterpipe lounge menus on intention to quit smoking among young adults. Participants that view a waterpipe lounge menu in VR with health information report greater intention to quit smoking waterpipe tobacco compared to participants that view a waterpipe lounge without health information.*

**H5:** *There is an effect of a health information (warning message and nicotine content) on waterpipe lounge menus on perceived relative harm of waterpipe tobacco smoking among young adults. Participants that view a waterpipe lounge menu in VR with health information report greater perceived relative harm of waterpipe tobacco smoking compared to participants that view a waterpipe lounge without health information.*

**H6a:** *There is an effect of a health information (warning message and nicotine content) on waterpipe lounge menus on perceived risk of cancer from waterpipe tobacco smoking among young adults. Participants that view a waterpipe lounge menu in VR with health information report greater perceived risk of cancer from waterpipe tobacco smoking compared to participants that view a waterpipe lounge without health information.*

**H6b:** *There is an effect of a health information (warning message and nicotine content) on waterpipe lounge menus perceived risk of heart attack from waterpipe tobacco smoking among young adults. Participants that view a waterpipe lounge menu in VR with health information report perceived risk of heart attack from waterpipe tobacco smoking compared to participants that view a waterpipe lounge without health information.*

**H6c:** *There is an effect of a health information (warning message and nicotine content) on waterpipe lounge menus on perceived risk of decreased lung function from waterpipe tobacco smoking among young adults. Participants that view a waterpipe lounge menu in VR with health information report greater perceived risk of decreased lung function from waterpipe tobacco smoking compared to participants that view a waterpipe lounge without health information.*

**H7:** *There is an effect of a health information (warning message and nicotine content) on waterpipe lounge menus on perceived relative addiction of waterpipe tobacco smoking among young adults. Participants that view a waterpipe lounge menu in VR with health information report greater perceived relative addiction of waterpipe tobacco smoking compared to participants that view a waterpipe lounge without health information.*

**Aim 3:** Examine visual attention to content on waterpipe lounge menus in a virtual reality (waterpipe lounge) environment using eye tracking data.

**H8a:** *There is an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the number of fixations on the menu. Participants that view a waterpipe lounge menu in VR with health information look at the menu more often compared to participants that view a waterpipe lounge menu without health information.*

**H8b:** *There is an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the number of fixations on the flavor area of the menu. Participants that view a waterpipe lounge menu in VR with health information look at the flavor area less often compared to participants that view a waterpipe lounge menu without health information.*

**H8c:** *There is an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the number of fixations on the nicotine*

area of the menu. Participants that view a waterpipe lounge menu in VR with health information look at the nicotine area of the menu more often compared to participants that view a waterpipe lounge menu without health information.

**H8d:** There is an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the number of fixations on the warning message area of the menu. Participants that view a waterpipe lounge menu in VR with health information look at the warning message area of the menu more often compared to participants that view a waterpipe lounge menu without health information.

**H8e:** There is an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the number of fixations on the ingredient area of the menu. Participants that view a waterpipe lounge menu in VR with health information look at the ingredient area of the menu more often compared to participants that view a waterpipe lounge menu without health information.

**H9a:** There is an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the dwel time on the menu. Participants that view a waterpipe lounge menu in VR with health information look at the menu for a longer period compared to participants that view a waterpipe lounge menu without health information.

**H9b:** There is an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the dwel time on the flavor area of the

menu. Participants that view a waterpipe lounge menu in VR with health information look at the flavor area menu for a shorter period compared to participants that view a waterpipe lounge menu without health information.

**H9c:** There is an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the dwelt time on the nicotine area of the menu. Participants that view a waterpipe lounge menu in VR with health information look at the nicotine area of the menu for a longer period compared to participants that view a waterpipe lounge menu without health information.

**H9d:** There is an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the dwelt time on the warning message area of the menu. Participants that view a waterpipe lounge menu in VR with health information look at the warning message area of the menu for a longer period compared to participants that view a waterpipe lounge menu without health information.

**H9e:** There is an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the dwelt time on the ingredient area of the menu. Participants that view a waterpipe lounge menu in VR with health information look at the ingredient area of the menu for a longer period compared to participants that view a waterpipe lounge menu without health information.

### **1.5. Brief Justification (Purpose of the Study)**

In 2009, the Family Smoking Prevention and Tobacco Control Act (FSPTCA) granted the FDA authority to regulate the manufacture, marketing and sale of tobacco products (U.S. Department of Health and Human Services, 2009). Initially, the FSPTCA gave the agency regulatory authority over cigarettes and smokeless tobacco, but this was extended in May 2016 to other tobacco products, including waterpipes (U.S. Department of Health and Human Services, 2016). However, there is limited research on health warnings and labeling of non-cigarette tobacco products. FDA needs strong, scientific evidence to support how these alternative tobacco products should be marketed and labeled to the public, especially to protect at-risk groups such as young adults. A challenge specific to waterpipe tobacco is that many consumers use the product in lounge environments and do not interact with the tobacco packaging, but rather the waterpipe device (Mostafa & Mohammed, 2017). Therefore, the waterpipe device or associated components such as the menus in the lounges may be more opportune locations for delivery of health warning messages. As it may not be practical to apply manipulations to waterpipe devices or menus in the real-world setting (lounges) for experimental testing, online and immersive virtual reality (VR) environments are useful tools for researchers.

The studies described in this dissertation utilized two different experimental environments, online and virtual reality in a laboratory, to examine the content on waterpipe lounge menus on the outcomes discussed in Aims 1 through 3. There is limited research on correcting misperceptions of WTS harm and risk (Wasim Maziak et al., 2015). First, the online experiment (Study 1) allowed investigators to understand the value of health warning messages and nicotine content. The virtual reality experiment (Study 2) provided a more real-world (feasibility) experience to further test the menu content on the selected outcomes. The state-of-

the-art virtual reality system completely immerses research participants inside a virtual waterpipe lounge, allowing them to experience real-life places, objects and sounds unlike any other laboratory environment. Additionally, using virtual reality as an investigation tool, this study expands the research on technology applications to address questions in tobacco use prevention and control. Through these methods, this research experimentally tests health information on waterpipe lounge menus to better understand the influence on intention to quit smoking, as well as the perceptions of harm, risk and addiction. Future work in tobacco risk communication can build on these findings to design effective health communication experiments for ATPs using VR. More importantly, the findings may directly support practice and policy decisions for health warning messages of non-cigarette tobacco products. Regulatory agencies may be better informed on communication strategies to educate the public about the health risks associated with WTS. This is crucial as alternative tobacco products increase in popularity in the U.S.

## **1.6. Definition of Variables and Terms**

**Alternative tobacco products**— adapted from the work of (Getachew et al., 2018) this includes little cigars, cigarillos, waterpipes, dissolvables and electronic nicotine delivery systems.

**Area of Interest**— a specific subset of graphic elements, regions or features that is of particular interest to a given analysis of eye tracking measures (Pieters & Wedel, 2008).

**Current Waterpipe Tobacco Use**—self-reported use of waterpipe tobacco every day or some days (*2013-2014 National Adult Tobacco Survey (NATS) Sample Design and Methodology Report*, 2016).

**Dwell Time**— one ‘visit’ to a relevant part of an ‘area of interest’ from when a participant first focuses on a region until the person looks away from that region (Pieters & Wedel, 2008).

**Ever Waterpipe Tobacco Use**— self-reported use of waterpipe tobacco at least once in a lifetime, but not every day or some days (*2013-2014 National Adult Tobacco Survey (NATS) Sample Design and Methodology Report*, 2016).

**Eye-tracking**— a process of measuring either the point of gaze (where one is looking) or the motion of an eye relative to the head (Pieters & Wedel, 2008).

**Fixation**— a period of time when the focus of the participant’s gaze is relatively still on an area and taking in visual information (Pieters & Wedel, 2008).

**Intention to Quit**— one’s willingness or degree of motivation to stop smoking (*2013-2014 National Adult Tobacco Survey (NATS) Sample Design and Methodology Report*, 2016).

**Nicotine Addiction**— a state of compulsive use of a nicotine (tobacco) product, even while knowing it is harmful (Benowitz, 2010).

**Perceived Relative Addiction**— specific to this study, this characterizes the awareness for compulsive waterpipe use (compared to cigarette use) despite knowing the harmful consequences.

**Perceived Relative Harm**— specific to this study, this includes any impairment or adverse effect to the health of an individual from waterpipe use (compared to cigarette use).

**Perceived Risk**— specific to this study, this describes the chance (high or low) that waterpipe use will cause an individual harm.

**Shisha**—a flavored tobacco mixture that is smoked in waterpipe.

**Tobacco Product**—any product made or derived from tobacco that is intended for human consumption, including any component, part, or accessory of a tobacco product. This includes cigarettes, little cigars, cigarillos, cigars, smokeless tobacco, waterpipe tobacco and electronic nicotine delivery systems (U.S. Food and Drug Administration, 2014).

**Virtual Reality**— a computer-generated environment designed to simulate a person's physical presence in a specific setting, often achieved using hardware such as a headset (Parisi, 2015).

**Waterpipe Tobacco Smoking**— a device used to smoke a moist, often flavored tobacco that passes through a water basin (Maziak et al., 2004).

**Young Adult**— specific to this study, this group includes adults between the ages of 18-24 years residing in the United States.

## Chapter 2: Literature Review

### 2.1 Origins of Waterpipe Tobacco Smoking

Waterpipe (also known as “*hookah*”, “*shisha*”, “*hubble-bubble*”, “*goza*”, “*galyan*” or “*narghileh*”) is an apparatus used to smoke a moist, often flavored tobacco (Baumler, 2013; Goodman, 2005). Although the exact origin is debatable, and numerous forms of waterpipe exist across the world, historical accounts suggest India or Persia as the beginnings of the smoking device (Baumler, 2013; Goodman, 2005; Razpush, 2000; Sivaramakrishnan, 2001). The most widely described story of the invention of waterpipe is in the 16<sup>th</sup> century by a Persian physician in the Indian court of Emperor Akbar (Razpush, 2000; Sivaramakrishnan, 2001). The device was said to be a safer method for consumption of tobacco because the smoke passed through water for purification. Another written account by the Persian poet, Ahli Shirazi, in 1535 refers to “*galyan*” or an early waterpipe device, making it possible that it was introduced into India from Persia (Razpush, 2000). Although tobacco is thought to have been brought into Persia and India by the Portuguese in the 17<sup>th</sup> century (Razpush, 2000; Sivaramakrishnan, 2001), it is likely that the early waterpipe in India was used to consume substances other than tobacco, such as cannabis or opium (Goodman, 2005). The practice of smoking tobacco through the WTS soon spread across Asia, the Middle East, the Mediterranean and Northern Africa through trade routes where the cultural tradition of use has persisted over time (Baumler, 2013; Goodman, 2005).

### 2.2 Anatomy of a Waterpipe

From region to region, waterpipes vary in size, shape, structure and tobacco smoked; however, the unifying feature is a water basin through which smoke passes before being inhaled by the user (Radwan et al., 2003). The first waterpipe in India was a primitive device made from

a hollowed coconut shell with bamboo reeds as pipe stems (Baumler, 2013). The modern waterpipe (Figure 2) consists of four components: a bowl (clay or ceramic), body/stem (metal or wood), base/vase (metal or glass), and hose (leather or nylon) (Maziak et al., 2004; Monzer et al., 2008; Maziak et al., 2009; Shihadeh et al., 2015). The body contains a hollow stem that extends from within the base to the bowl at the head of the waterpipe. One or more flexible hoses with a mouthpiece attaches to the body. Today as a hygiene practice, waterpipe users often attach a plastic, disposable mouthpiece to limit the spread of germs.

During the smoking process, the base is partially filled with water, so that the stem is submerged (Maziak et al., 2004). The moist, flavored tobacco is packed into the bowl and covered with perforated foil sheet, and an indirect heat source, normally charcoal, is placed over the foil sheet to burn the tobacco (Monzer et al., 2008). The smoker draws on the hose to generate smoke and further accelerate the burning of the tobacco (Shihadeh et al., 2015). The smoke from the burning tobacco travels down the stem of the instrument and into the water-filled base causing it to

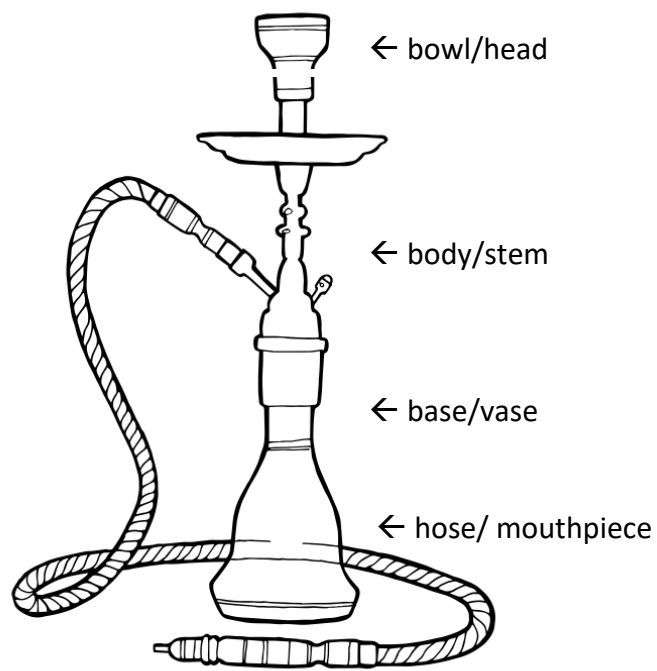


Figure 2. Anatomy of the Waterpipe

bubble (Maziak et al., 2004). The smoke then rises from the base and travels through an opening to the hose to be inhaled by the smoker (Shihadeh et al., 2015). Sometimes the water base is filled with ice, alcohol, juice, energy drinks or milk (Griffiths et al., 2011). These different

modifications are used to cool the smoke, add flavor or thicken the smoke cloud exhaled by the user.

## **2.3 Global Emergence of Waterpipe Tobacco Smoking**

It is difficult to pinpoint the exact reasons why waterpipe has gained popularity across the globe. However, the World Health Organization has suggested four unique factors that have contributed to the rapid emergence beyond the regions of traditional use: introduction of flavored tobacco, development of café and restaurant culture, mass communication and gap in waterpipe-specific policies (World Health Organization & WHO Study Group on Tobacco Product Regulation, 2015).

### 2.3.1 Introduction of Flavored Tobacco

In the 1990s, the manufacturing of flavored tobacco referred to as *maassel* turned what was a pastime of elderly men in the Middle East into a staple leisure activity of young people, particularly university students (Kandela, 2000; Rastam et al., 2004). Prior to the use of *maassel*, raw tobacco was crushed, mixed with water and packed into the bowl of the waterpipe for smoking (Maziak et al., 2004). This resulted in a strong, harsh smoke. Conversely, *maassel*, is a moist, tacky mixture of fermented tobacco with molasses, glycerin and fruit flavors (Shihadeh et al., 2015). The mixture produces a smooth, aromatic smoke that is palatable for the user to inhale and also is easier for users to prepare in the waterpipe (Rastam et al., 2004).

### 2.3.2 Café and Restaurant Culture

Beyond the Middle East, waterpipe cafes and bars operate in several European and American cities. The introduction to the Western world (1960s-70s) is in part credited to tourists

returning from the Middle East, but also the immigrants from this region opening these businesses in their new communities (Salvi, 2016). In the United states, waterpipe cafes are often in areas with dense ethnic communities or college students (Sutfin et al., 2011). In fact, one study found that WTS among university students was correlated with the presence of a waterpipe lounge or café within a 10-mile radius from campus (Salloum, Osman, et al., 2015).

Additionally, the social dimension is an appeal for initiation and continuation among young adults.(Akl et al., 2015; Maziak, 2011; Maziak et al., 2004). For example, some venues offer a variety of Mediterranean food and even alcohol, whereas others may attract customers through belly dancers, musical performances or free Wi-Fi access (Primack, Rice, et al., 2012). In contrast from cigarette smoking, the WTS is intended to be a communal experience where users may smoke one product/device in a social environment.

### 2.3.3 Mass Communication

WTS is present on all the major social media platforms including Facebook, Twitter, Instagram, YouTube, and Pinterest. The rise of social media platforms as a method of mass communication helped the practice gain social acceptability and move beyond the traditional geographic regions of use (Allem, Chu, et al., 2017; Allem, Ramanujam, et al., 2017; Carroll et al., 2013; Grant & O'Mahoney, 2016; Guidry et al., 2016; Jackler et al., 2018; Krauss et al., 2015; Primack, Rice, et al., 2012; Primack, Carroll, Shensa, et al., 2016; Salloum, Osman, et al., 2015). Waterpipes have been promoted directly by retailers and through consumer posts on social media personal profiles (Primack, Rice, et al., 2012). Social media has allowed waterpipe businesses to reach customers directly and portray themselves as “interest groups” or consumers (Primack, Rice, et al., 2012).

Social media sites such as Facebook have advertising policies to prevent the promotion and sale of tobacco products and paraphernalia; however, according to online terms, “blogs or groups connecting people with tobacco-related interests, as long as the service does not lead to the sale of tobacco or tobacco-related products” are allowable (Facebook, n.d.). Interestingly, a study of Facebook content found purchase links (e.g., ‘shop now’ button) on waterpipe tobacco brand-sponsored pages (Jackler et al., 2018), which is in violation of the Facebook advertising policy.

Collectively, across the various online platforms, social media was less likely to communicate the risks of WTS and more likely to communicate the allure of WTS. Research on the Instagram platform revealed the presence of promotional images from waterpipe lounges, as well as personal accounts (Allem, Chu, et al., 2017; Ben Taleb et al., 2018). In one study, users posted images of their customized waterpipes in a variety of shapes, sizes, and styles, as well as their WTS tricks (Allem, Chu, et al., 2017). Studies of WTS content on Twitter have shown an association with positive emotions such as active, alert, happy, pleasant, as well as normalizing WTS and advertising WTS establishments (Allem, Ramanujam, et al., 2017; Grant & O’Mahoney, 2016; Krauss et al., 2015). In a study by Carroll, Shensa and Primack, WTS videos on YouTube were more likely to depict the act as positive in comparison to cigarette-related videos (Carroll et al., 2013). The study revealed that WTS videos were more likely to describe “smoking tricks” or “how-to’s” rather than information on potential health effects, guidance for quitting or any antismoking message. Similarly, positive messages of pleasure, beauty and relaxation from WTS were found on Pinterest (Guidry et al., 2016).

#### 2.3.4 Policy Gaps

Finally, the lack of waterpipe-specific policies has made it easy for the industry to thrive. Many of the strong tobacco control policies that regulate product marketing and sales have been focused on cigarettes and unclear about other tobacco products, allowing for waterpipe promoters and business to flourish largely unregulated (Colditz et al., 2016). The WTS policy landscape is slowly improving in the US. In August 2016, the Center for Tobacco Products (CTP) at the U.S. Food and Drug Administration (FDA) finalized a rule expanding their authority for regulating the manufacture, marketing and sales of products that meet the definition of a tobacco product, including e-cigarettes, cigars, pipes and waterpipes (Center for Tobacco Products, 2018b). The rule established a national minimum age for sales; requires health warnings on packaged products and ingredient labels and warrants FDA pre-market review of new and modified tobacco products. Most of the regulations went into effect immediately; however, the policies mandating the nicotine addictiveness warning statements were delayed until August 2018. Unfortunately, these lags in policy and regulatory action further contribute to the spread of WTS (Colditz et al., 2016; Haddad et al., 2015).

A continued challenge in the policy realm is that WTS is distinct from conventional forms of tobacco, such as cigarettes. The smoking process involves three parts that each present special considerations for policy implications: the tobacco, the heating source and the device (Sutfin et al., 2018). First, there is no legal standard for a health warning label or ingredient for waterpipe tobacco packaging (Salloum, Maziak, et al., 2015). Additionally, the location of smoking (cafes, lounges and bars) presents several policy concerns and arguably, one of the main policy gaps in the regulation of the waterpipe industry. In the early days as WTS grew in the US, these businesses operated with minimal legal barriers, which allowed for deceptive advertising

practices (i.e. stating 0% tar on waterpipe tobacco packaging), poor quality control and potential tobacco product access to minors (Mohammed Jawad et al., 2013; Primack, Rice, et al., 2012). Numerous waterpipe lounges function in the US under an exemption to clean indoor legislation (Legal Resource Center for Public Health Policy, 2013; M. P. Martinasek et al., 2015; Noonan, 2010; Primack, Hopkins, et al., 2012). The exemption allowed for waterpipe lounges to function as tobacco retailers rather than traditional restaurants or bars. These establishments, unlike most bars in the US, did not have strict age restrictions for patrons. Most allowed entrance to persons under the age of 21 (minimum age being 18 prior to the federal Tobacco 21 policy), particularly when alcohol is not served on the menu (Primack, Rice, et al., 2012).

However, the pace of policy change for WTS has lagged the scientific evidence, and during this time, WTS has continued to gain popularity among new users. Tobacco control policies must be revised and developed in the context of WTS to address these challenges and protect young adults at risk of becoming lifelong smokers (Haddad et al., 2015). Furthermore, policies still need to be explored equalizing tobacco product tax rates, warning labels on the waterpipe device itself, ban of flavors and removal of legal exemption from clean indoor air laws (Morris et al., 2012).

## **2.4 Health Consequences of Waterpipe Tobacco Smoking**

Alternative tobacco products, such as waterpipes, are promoted as less harmful than cigarettes and are increasing the amount of non-daily tobacco users (Blachman-Braun et al., 2014). Lack of understanding and awareness of the health risks of WTS and likelihood of addiction contribute to the increase in its popularity (Griffiths & Ford, 2013; Heinz et al., 2013; Sterling et al., 2015; Sterling & Nix, 2014). These misconceptions include that WTS is safer than

cigarette smoking, does not lead to serious disease, does not contain nicotine, the water filters the potential harmful chemicals in smoke and does not lead to tobacco addiction. However, a growing body of research has shown that WTS is harmful to health of those that are actively and passive exposed to the tobacco smoke and has the potential for addiction to nicotine.

#### 2.4.1 Toxicity of Waterpipe Smoke

Waterpipe smokers are exposed to smoke in two ways—the burning tobacco and the burning coal. A misrepresentation is that WTS is safer than cigarette smoking, because the water in the base of the waterpipe filters the toxic components of the tobacco smoke. However, a systematic review of toxicological studies on waterpipe tobacco smoke identified 82 of the 98 toxicants from the Hoffmann list of hazardous smoke components that are associated with tobacco-related diseases (Shihadeh et al., 2015). This review found that many of the hallmark toxicants of cigarette smoke such as tar, carbon monoxide, polycyclic aromatic hydrocarbons, heavy metals and several carcinogens were reported in studies of waterpipe smoke and sometimes in greater amounts than cigarette smoke. An important point for consideration in drawing comparisons of human smoke exposure across tobacco products is the difference in smoking or puff patterns. First, the average cigarette smoker takes roughly ten puffs on a cigarette over five minutes (Hoffmann & Hoffman, 1997). In contrast, a laboratory study by Maziak et al. found that a single WTS session averaged thirty-three minutes with 170 puffs (Maziak et al., 2009). A direct comparison of toxicant exposure of waterpipe tobacco and cigarette smoking by Eissenberg and Shihadeh found that WTS was linked to greater carbon monoxide and total smoke exposure (Eissenberg & Shihadeh, 2009). This study reported an average puff volume of 48.6 L for WTS compared to 1.0 L for cigarette smoking (Eissenberg &

Shihadeh, 2009). Similarly, a study of relative exposure showed in a normal waterpipe session, the smoke exposure was equivalent to about twenty-five cigarettes worth of tar, eleven cigarettes worth of carbon monoxide and 2 cigarettes worth of nicotine (Primack, Carroll, Weiss, et al., 2016). Aboaziza and Eissenberg also documented that differences in the amount of tobacco by weight between these two products, finding that a single cigarette contained about one gram of tobacco compared to a single waterpipe bowl that contained anywhere from ten to twenty grams of tobacco (Aboaziza & Eissenberg, 2014). The charcoal used to heat the waterpipe tobacco also raises concerns due to the concentrations of heavy metals, such as lead, that are associated with health risks (Elsayed et al., 2016), as well as carbon monoxide and polyaromatic hydrocarbons (Monzer et al., 2008). In an acute laboratory study, waterpipe smokers reported subjective health effects of nicotine consumption such as being dizzy, lightheaded, nauseous (Maziak et al., 2009). The dizziness and nauseous feelings were thought to be direct effects of carbon monoxide poisoning (Eichhorn et al., 2018).

Finally, most toxicological studies of waterpipe smoke were in the laboratory environment and examined individual smoking patterns. However, WTS characteristically takes place in group settings, so there are limitations of the laboratory environment in replicating naturalistic smoking behaviors. One study attempted to imitate this natural smoking pattern by observing individual and dyad WTS (Ramoal et al., 2016). The study described that when participants smoked in pairs, they took on average more puffs than a single smoker, shorter times between puffs and exhaled higher concentrations of the toxicants. Together, these studies support a pattern in the research literature that waterpipe tobacco smoke is associated with exposure to harmful substances. However, it is a challenge to understand the exact placement of this product

on a continuum of harm of all tobacco products given the differences in the tobacco characteristics, form of consumption and smoking behaviors.

#### 2.4.2 Passive Smoke Exposure

Evidence shows that WTS also exposes nonusers to several toxicants that are risk factors for adverse health outcomes. Though US most states have comprehensive clean indoor air laws, waterpipe lounges are often excluded from these policies (Noonan, 2010). Also, while there are laws that detail the ventilation needed for locations that permit indoor smoking (i.e. cigar bars), poor air quality, because of the accumulation of smoke or movement of smoke to nonsmoking areas, remains a key issue (Noonan, 2010). Numerous studies examined the overall air quality in waterpipe lounges. For example, a field study reported that patrons (those that do or do not smoke) and workers at waterpipe lounges were exposed to hazardous levels of carbon monoxide, particulate matter (PM<sub>2.5</sub>) and airborne nicotine (M. P. Martinasek et al., 2014). Similarly, a study of secondhand smoke exposure concluded that waterpipe lounges were an occupational hazard for the employees (Zhou et al., 2017). Employees had significantly high levels of carbon monoxide at the completion of their work shifts (Zhou et al., 2017). According to the work of Fiala, Morris and Pawlak, waterpipe lounges were found to have “unhealthy” to “hazardous” PM<sub>2.5</sub> measurements as set by the U.S. Environmental Protection Agency’s Air Quality Index (Fiala et al., 2012). In this particular study, not one waterpipe lounge was found to have “good” air quality. Relative to other establishments that permit indoor cigarette smoking, it was reported that waterpipe lounges have greater PM<sub>2.5</sub> measurements (Cobb et al., 2013; Travers et al., 2018). Furthermore, air quality only worsened as the number of waterpipes increased in the establishment (Zhou et al., 2015). An observational study of waterpipe lounges also found that even when the venues had marked non-smoking rooms (mainly in the restaurant-style

establishments), the doors were not consistently closed to prevent contamination of air, so elevated levels of PM<sub>2.5</sub> levels were found in non-smoking rooms (Cobb et al., 2013). This study also raised concerns about the exposure to thirdhand smoke, which refers to the pollutants trapped in the furniture or walls (Cobb et al., 2013). These studies demonstrate the need for regulations that protect the health of workers and customers at waterpipe lounges.

### 2.4.3 Health Effects

The global emergence of waterpipe over the last two decades has pushed more research into the health effects associated with WTS. Although published studies that examine the health outcomes for WTS are limited in comparison to cigarette smoking, initial epidemiological investigations have shown a significant association with cardiovascular disease (Alomari et al., 2015; Azar et al., 2016; Blank et al., 2011; Cobb et al., 2012; Hakim et al., 2011; Islami et al., 2013; Sibai et al., 2014; Wu et al., 2013), respiratory illness (Al-Fayez et al., 1988; Hakim et al., 2011; Hawari et al., 2013; Khabour et al., 2018; Layoun et al., 2014; P. Salameh et al., 2012; Strulovici-Barel et al., 2016; Waked et al., 2011), low birth-weight (Nuwayhid et al., 1998; Tamim et al., 2008), infertility (Ali et al., 2017), oral disease (Al-Belasy, 2004; Baljooon et al., 2005; Bibars et al., 2015; Javed et al., 2016; Khemiss et al., 2016; Natto et al., 2005a, 2005b) and cancer (Al-Amad et al., 2014; Aoun et al., 2013; Dar et al., 2012; Gupta et al., 2001; Koul et al., 2011; Lubin et al., 1990; Mamtani et al., 2017; Nasrollahzadeh et al., 2008).

*Cardiovascular effects.* WTS has been linked to acute cardiovascular effects, such as increased heart rate and blood pressure (Alomari et al., 2015; Azar et al., 2016; Blank et al., 2011; Cobb et al., 2012; Hakim et al., 2011), as well as chronic cardiovascular outcomes such as heart disease or heart failure (Islami et al., 2013; Sibai et al., 2014). For example, in a laboratory

study of acute physiological changes after a WTS session, immediate changes in vascular function were noticed among participants (Alomari et al., 2015). Similarly, double-blind, placebo-control study found increased heart rates (Blank et al., 2011), and a crossover study found that heart rate variability decreased after smoking sessions (Cobb et al., 2012). When compared with cigarette smoking, a study found increased heart rate among waterpipe smokers (Layoun et al., 2014).

Physiological effects have also been studied in real-life smoking settings through field observations and experiments. For example, a study in Lebanon examined the blood pressure and heart rate of active and passive exposure to waterpipe in a restaurant that served waterpipe (Azar et al., 2016). Measurements were taken from patrons that were smoking, patrons seated at the same table as a smoker (but not smoking) and patrons seated in a nonsmoking part of the restaurant. The patrons actively smoking waterpipe had increased heart rate and blood pressure consistent with the laboratory-based studies of physiological effects.

Observational studies have also assessed the relationship with chronic disease outcomes. In a population-based, cross-sectional study in Iran, researchers found a significant association with heavy WTS and prevalence of heart disease such that waterpipe smokers were four times more likely to have heart disease compared to nonsmokers of waterpipe (Islami et al., 2013). The increased risk was observed even among never cigarette smokers. A comparable cross-sectional study of hospital patients admitted for cardiovascular procedures in Lebanon found that lifetime exposure to waterpipe smoke was associated with coronary artery disease, nearly three times that of nonsmokers (Sibai et al., 2014). The relationship remained after adjustments for common risk factors such as diabetes or cigarette smoking.

*Respiratory effects.* For years, research studies have shown an association between WTS and poor respiratory effects including pulmonary function, respiratory rate, oxygen consumption and decreased exercise capacity (Al-Fayez et al., 1988; Waked et al., 2011; Hakim et al., 2011; P. Salameh et al., 2012; Hawari et al., 2013; Layoun et al., 2014; Khabour et al., 2018; Strulovici-Barel et al., 2016). A case-control study in Lebanon established a strong association between ever using waterpipe and chronic bronchitis (P. Salameh et al., 2012). Research has also established an association between WTS and COPD. A cross-sectional study of chronic obstructive pulmonary disease (COPD) prevalence in Lebanon, waterpipe smokers 40 years and older had an increased risk (OR = 2.53) of developing COPD (Waked et al., 2011). According to Strulovici-Barel et al., even among young adults that were light, waterpipe-only users, changes to their lung components were observed that make them susceptible to future health issues (Strulovici-Barel et al., 2016). There were clear clinical pulmonary abnormalities, increased cough and saliva/mucus from the respiratory track, decreased diffusing capacity and cellular changes in the lung tissue, in the young adults waterpipe smokers compared to the nonsmokers (Strulovici-Barel et al., 2016). These clinical parameters are common to respiratory disease or infection. Additionally, experimental studies of respiratory effects have been conducted using animal models. Khabour et al. found that mice that were regularly exposed to waterpipe smoke (one hour/day for five days/week for six weeks) had an inflammatory response in the airway (Khabour et al., 2018).

*Oral disease.* Research shows the toll of WTS on oral health is comparable to cigarette smoking. The bacterial contamination in waterpipes, particularly the mouthpieces, have been found to contain a high prevalence and diversity of bacteria (some antibiotic-resistant strains) (M. Martinasek et al., 2018). A study of pre-operative and post-operative smoking habits on the

risk of developing dry sockets found that waterpipe smokers had three times the risk compared to nonsmokers (Al-Belasy, 2004). A cross-sectional study of cigarette and waterpipe smokers in Saudi Arabia found an association with vertical bone loss and WTS, comparable to cigarette smoking (Baljoon et al., 2005). Another study estimated that waterpipe smokers are four times more likely than non-tobacco users to develop periodontal disease (Bibars et al., 2015). A cross-sectional study of Tunisian males who had smoked waterpipe for five or more years, found that waterpipe smokers had a higher plaque index, but similar periodontal bone height and bone loss frequency (Khemiss et al., 2016).

*Cancer.* The association between cigarette smoking and various types of cancer has been extensively studied and is well established in research literature. However, the link between WTS and cancer is more limited. Despite the popular belief that WTS is a safer form of tobacco consumption, it has been linked to head and neck, esophagus, stomach, bladder and lung cancer (Mamtani et al., 2017). Lung cancer has been the primary cancer outcome research in waterpipe tobacco smokers, and some case-control studies report a strong association of WTS with lung cancer (Aoun et al., 2013; Gupta et al., 2001; Koul et al., 2011; Lubin et al., 1990). One of the earliest case-control studies was a sample of male Chinese tin miners in a community where waterpipe was the primary methods of tobacco consumption (Lubin et al., 1990). The study found an increase in lung cancer risk with cumulative exposure to WTS. Similarly, WTS was significantly correlated with lung cancer in a hospital sample of Lebanese adults (Aoun et al., 2013). In a sample from India, waterpipe smokers were nearly six times at risk for lung cancer as compared to nonsmokers (Koul et al., 2011). A review of oral cancer patients in the Jordanian National Cancer Registry found that waterpipe smokers were diagnosed with oral cancer and a younger age than nonsmokers even when controlling for gender, cigarette smoking and alcohol

use (Al-Amad et al., 2014). Case-control studies in Iran and India on esophageal cancer have also suggested an increased risk with greater exposure to WTS (Dar et al., 2012; Nasrollahzadeh et al., 2008).

#### 2.4.4 Addiction to Waterpipe tobacco smoking

Cigarettes are among the most addictive consumer goods in our society—the key culprit being nicotine. Although nicotine does not directly cause tobacco-related diseases, it is responsible for the high rates of dependence to tobacco products. It is this dependence or addiction that leads to prolonged exposure to the toxic chemicals that lead to tobacco-related morbidity and mortality. Nicotine delivery through smoking is rapid. Once inhaled it is absorbed into the blood circulation and enters the brain within 10 seconds (Benowitz, 2010). It causes a huge boost of dopamine in the brain, which is responsible for “high” feelings associated with smoking, and dopamine plays a critical role in drug reinforcement—motivating a person to seek the pleasurable “high” feelings again, and thus, facilitates addiction (Benowitz, 2010). WTS is increasingly becoming the first tobacco product used by young adults, and a potential gateway to other tobacco product use in the future (Doran et al., 2015; Jaber et al., 2015; Kulak et al., 2018; Meier et al., 2015; Veeranki et al., 2015).

In nicotine, naïve-persons, WTS is likely to increase the susceptibility to other tobacco product use. A product characterization study by Hadidi and Mohammed found that the common types of waterpipe tobacco do contain nicotine (contrary to the belief of some users) with an average concentration of 3.4 mg/g of flavored tobacco (Hadidi & Mohammed, 2004). Although the study noted that this was much less tobacco than common brands of cigarettes (13.8 mg/g), it is important to consider the difference in smoking patterns (the number of puffs, the duration of puffs and amount of tobacco per smoking session) between each product to understand the

potential for nicotine dependence. Therefore, it was reasonable that waterpipe smokers in the laboratory reported withdrawal symptoms similar to cigarette smoking such as restlessness, urges and cravings (Aboaziza & Eissenberg, 2014). Moreover, waterpipe smokers in the laboratory reported similar “subjective profiles” as cigarettes smokers following a WTS session, such as pleasure, satisfaction or reduced urge to smoke (Aboaziza & Eissenberg, 2014). Even at low levels of consumption and low levels of frequency of use, these symptoms of nicotine dependence, were present in waterpipe smokers (Bahelah, DiFranza, Fouad, et al., 2016; Bahelah, DiFranza, Ward, et al., 2016). Even more troubling, waterpipe tobacco is increasingly becoming the first tobacco product used by young adults, and a potential gateway to other tobacco product use in the future (Doran et al., 2015; Jaber et al., 2015; Kulak et al., 2018; Meier et al., 2015; Veeranki et al., 2015).

## **2.5 Epidemiology of Waterpipe Tobacco Smoking in Young Adults**

In the United States, adult tobacco prevalence is monitored by several national surveillance systems such as the National Adult Tobacco Survey (NATS) by the Office on Smoking and Health at the Center for Disease Control and Prevention, the National Survey on Drug Use and Health by the Center for Behavioral Health Statistics and Quality and more recently, the Population Assessment of Tobacco and Health (PATH) Study by the Center for Tobacco Products at the FDA. Over recent years there has been better consensus among these tobacco surveillance tools on standard measures and terminology for the assessment of WTS. This has allowed for more accurate tracking and understanding of WTS trends in the U.S. population.

The NATS, a national, representative survey, has been the leading source of data on tobacco prevalence in the U.S. and provides a snapshot of recent WTS patterns among adults (Center for Disease Control and Prevention, 2018). It assesses WTS by the following question: “Do you now smoke tobacco in a hookah every day, some days, rarely or not at all?” Current waterpipe smokers are defined as those that report waterpipe use at least once during their lifetime and now use “every day” or “somedays.” Intermittent smokers are as those that report waterpipe use at least once during their lifetime and now use waterpipe use “rarely,” and those that report using waterpipe “not at all” are defined as nonusers.

The two most recent CDC reports of the NATS data indicated an increasing ever use of waterpipe tobacco (at least once during their lifetime) among adults in the U.S from 3.9% in 2012–2013 (Agaku et al., 2014) to 4.3% in 2013–2014 (Hu, 2016). Moreover, young adults ages 18–24 years report the highest rates of WTS among adults of all age groups. In 2013-2014, 20.2% of young adults reported ever use of waterpipe tobacco compared to 18.2% in 2012-2013 (Agaku et al., 2014; Hu, 2016). Current use has increased as well—in 2013-2014, 3.2% of young adults in the U.S. reported smoking waterpipe “every day” or “someday” compared to 2.5% in 2012-2013 (Agaku et al., 2014; Hu, 2016). Among adults of all age groups, 0.6% reported smoking waterpipe “every day” or “someday” in 2013-2014 (Hu, 2016). These categories of WTS frequency are important as research has indicated that compared to cigarette smoking, waterpipe smokers are more intermittent users (W. Maziak et al., 2005).

The PATH Study reported much higher rates of ever and current WTS in the U.S. In contrast to other national surveys for tobacco surveillance, the PATH Study is the first population-based, longitudinal study of tobacco use behaviors (Center for Tobacco Products, n.d.). The 2013-2013 PATH Study data reported that 16.4% of adults have smoked waterpipe in

their lifetime, and among daily/weekly waterpipe smokers, 66.3% were young adults 18 to 24 years of age (Robinson et al., 2018). Specifically, among young adults, 44.3% reported ever use (lifetime) and 10.7% current use (every day and someday) of WTS (Kasza et al., 2017). The prevalence rates of WTS in young adults has also been assessed through numerous university-based, cross-sectional studies, and these studies have found waterpipe ever use rates from 30% to 48% and current use rates from 7% to 22% of the surveyed population (Noonan et al., 2011; Sutfin et al., 2011; Jarrett et al., 2012; Heinz et al., 2013; Barnett et al., 2013; Primack et al., 2013; Montgomery et al., 2015; Haider et al., 2015; Kothari & Berg, 2018). The PATH study utilized in-person interviews with tobacco product images; this may have addressed limitations of other tobacco surveillance tools such as underreporting tobacco use due to response options not reflecting true patterns of use or confusion with the vocabulary for various tobacco products (Corey et al., 2014). It may also explain the variance in rates reported by the PATH Study compared to the NATS. Additionally, the difference in prevalence rates may be explained by varying definitions of current, ever and never WTS. Nonetheless, most tobacco surveillance tools confirm a public health problem with young adult WTS in the U.S.

## **2.6 Perceptions of Harm, Risk and Addiction**

WTS is perceived by young adults differently from other forms of tobacco use. Research on young adults' attitudes and perceptions have noted largely, positive attitudes toward WTS and perceptions of reduced health risks and addictiveness compared other forms of smoking (Eissenberg et al., 2008; Heinz et al., 2013; Noonan, 2013; Noonan & Kulbok, 2012; Primack et al., 2008; Smith-Simone et al., 2008). In these studies, WTS was more normalized and viewed as a social acceptable form of tobacco consumption. Generally, young adults perceived WTS to

have more benefits or positive attributes, such as the variety of pleasant tasting and smelling tobacco flavors, a means for a social gathering and bonding with friends and even a hobby for performing smoking tricks (Cornacchione et al., 2016; Noonan, 2013; Sharma et al., 2014; Smith-Simone et al., 2008). Moreover, young adults associated WTS with autonomy, novelty appeal, global awareness and entertainment (Castañeda et al., 2016). Studies have also demonstrated that young adults enjoy the “buzz” from WTS and view the experience as a time for relaxation and stress relief (Sharma et al., 2014; Smith-Simone et al., 2008).

Despite accumulating evidence that WTS presents harms similar to cigarette smoking, most young adults do not perceive health effects associated with WTS to be negative or serious enough to cause harm (Cornacchione et al., 2016; Getachew et al., 2018; Rayens et al., 2017). Many hold the common misconception that WTS was safer than cigarette smoking (Cornacchione et al., 2016; Majeed et al., 2017; Smith-Simone et al., 2008; Ward et al., 2007). For instance, many waterpipe smokers perceived the practice as “healthier” because of the fruit flavoring (Dugas et al., 2010). Additionally, the research literature also noted that many believed that the water in waterpipe acts as a filter to absorb all the toxic constituents in the tobacco, so they are exposed to far less intake of nicotine and carcinogens (Heinz et al., 2013; Sharma et al., 2014). These misconceptions have shown to be associated with smoking tobacco using a waterpipe in the literature (Primack et al., 2008). Studies showed that among current, former and never users of waterpipe there is low perceived addictiveness (Heinz et al., 2013; Mays, Arrazola, et al., 2016; Primack et al., 2008; Sharma et al., 2014; Smith-Simone et al., 2008; Ward et al., 2007). Interestingly, many waterpipe users were confident about their ability to quit (Mays, Arrazola, et al., 2016; Smith-Simone et al., 2008; Ward et al., 2007); however, they had low desire in quitting (W. Maziak et al., 2005; Smith-Simone et al., 2008; Ward et al., 2007).

## **2.7 Health Communication for Waterpipe Tobacco Smoking**

According to the U.S. Department of Health and Human Services, health communication is “the study and use of communication strategies to inform and influence individual and community decisions that enhance health” (U.S. Department of Health and Human Services, 2012). In the context of tobacco prevention and control, health communication can include a wide variety of methods in which information on tobacco and smoking is delivered to consumers and the public to prevent initiation and/or encourage cessation. These methods include a broad range of public health strategies such as public education or counter-marketing campaigns, community-level or individual-level health interventions and health warning messages on tobacco products. As tobacco remains the leading risk factor for death and disease in the United States, there is a great amount of evidence on the associated risks to consumers to communicate to the public. However, most of the health communication literature on tobacco products is focused on traditional cigarettes, and it not clear how effective or adaptable these strategies are for other tobacco products (Ross et al., 2017). Thus, further research is needed to better understand the most effective content and methods for implementing tobacco risk communication for alternative tobacco products. Research specific to waterpipes continues to develop in the following areas: health warning messages; product labels; public education campaigns; health interventions.

### 2.7.1 Health Warning Messages

As with most consumer products, the packaging of tobacco products is more than a medium for containment, but a tool for marketing to consumers. The tobacco industry has successfully designed packages that promote their brand imagery, appeal to young adults and

influence the perception of cigarette strength and taste (Wakefield et al., 2002). To combat these marketing efforts, health warning messages on tobacco products have been a useful tool to increase the knowledge of harms and perceptions of risk associated with tobacco use (David Hammond, 2011). For the case of cigarette packages, health warning messages have been shown to increase perceptions of health risks associated with smoking (Evans et al., 2018) and increase the number of quit attempts (Borland et al., 2009). As of August 2018, the U.S Food and Drug Administration (FDA) requires that all covered tobacco products, including waterpipe tobacco, carry the following messages: ‘*WARNING: This product contains nicotine. Nicotine is an addictive chemical.*’ (Center for Tobacco Products, 2018a). This message is comparable in sentiment to current health warnings on cigarette packages. The four current health warnings on cigarette packages have not been revised since 1984 and have been described as “stale, unnoticed and a major impediment to greater progress in reducing cigarette smoking” (Campaign for Tobacco Free Kids, 2018).

The World Health Organization and Institute of Medicine recommend graphic rather than text for health warnings; these recommendations come with strong evidence from scientific studies and real-world experiences that graphic warning labels on cigarette packages increase understanding of health risks associated with smoking for both smokers and non-smokers (Fong et al., 2009). Although the 2009 Family Smoking Prevention and Tobacco Control Act requires graphic health warnings on cigarette packages, lawsuits from the tobacco industry have delayed FDA’s implementation of this effort. Another challenge specific to waterpipe tobacco is that many consumers use the product in lounge environments and do not interact with the actual tobacco package, but rather the waterpipe device (Mostafa & Mohammed, 2017). This is different from traditional tobacco products such as the cigarette where users carry the pack and

view it multiple times a day and placement of the health warning messages are more easily viewed by users (D. Hammond et al., 2003). Thus, emerging research in this area is focused on how to understand the effectiveness of the content of health warning messages and product labels, as well as the placement this content on the waterpipe tobacco packages and devices.

One of the earliest descriptive studies by Nakkash and Khalil investigated existing health warning labeling practices on waterpipe tobacco products in Lebanon, Dubai, Palestine, Syria, Jordan, Bahrain, Canada, Germany and South Africa (Nakkash & Khalil, 2010). The study found that the majority waterpipe tobacco products had health text warning messages similar to those on cigarettes packs. Pertaining to placement, the text health warning messages were often on the side of the packages, occupied less than 4 percent of the total surface area and had no differentiation from other content on the package. Additionally, the study found that the ingredient disclosures were often inaccurate or misleading with statements such as 0.0% tar. This is misleading because tar is produced by the burning of tobacco and is not present in the unburnt waterpipe tobacco product.

A study that examined exposure among young adult waterpipe smokers in the United States to current warning messages on waterpipe tobacco packages (prior to the August 2018 mandated warnings by FDA) used data from the PATH Study and found that about 36% of young adult waterpipe smokers were exposed to a health warning message in the past 30 days (King et al., 2018). Among those that reported exposure to the warning messages, half reported the frequency of exposure as 'rarely.' Exposure to warning messages on waterpipe tobacco packages was greater among males, but there was no evidence for differences based on race, ethnicity, sexual orientation or income. Additionally, exposure to the warning messages was associated with those that usually did not share the same waterpipe with other, those that usually

purchased waterpipe tobacco and those that usually used a regular brand of waterpipe tobacco. Exposure to warning messages on waterpipe tobacco packages was not correlated with factors such as smoking frequency, owning a waterpipe or location of consumption (i.e. home versus café setting). Those that were exposed to warning messages on waterpipe tobacco packages were more likely to report that WTS is as or more harmful than cigarettes, but there was no relationship with changes (reduction) in waterpipe use.

Qualitative approaches have also been used to examine health warning messages. In a focus group study in London, waterpipe users were exposed to existing health warning messages on waterpipe tobacco packages, as well as hypothetical health warning messages developed to comply with current/future legislation for package labeling (Mohammed Jawad, Bakir, et al., 2015). An emerging theme from the focus group discussion was that the health warning messages were more effective in increasing awareness of the harms of WTS as they increased in size and as the waterpipe tobacco package became less “branded.” Additionally, waterpipe smokers emphasized that since many went to lounges to smoke, the tobacco came packed into the waterpipe bowl by the lounge staff, and they rarely, if ever, saw the tobacco in the original package. This is an important insight regarding message placement.

Similarly, a study in Lebanon utilized in-depth interviews of exclusive waterpipe smokers to evaluate the impact of shocking graphic health warning messages versus currently used text health warning messages on the packages of waterpipe tobacco (Layoun et al., 2016). This study found that the graphic health warning messages were more likely to influence the behavior of waterpipe smokers (intentions to quit) than text health warning messages. A third mixed-methods study in Egypt interviewed individuals and groups to evaluate the current graphic health warnings and newly designed health warning messages on packages (Mostafa & Mohammed,

2017). Researchers in the Egyptian study found that although current health warnings triggered emotional reactions, the graphics were unclear or unrealistic to waterpipe smokers. Health warnings with more proximal health risks were viewed as more effective by waterpipe smokers. Also, in this study, newly designed graphic health warnings messages were viewed more powerful warnings as they occupied more of the package, provided factual content on the ingredients and did not use bright, attractive colors or flavor names. Those interviewed felt that placing messages on the body or mouthpiece of the waterpipe would be favorable in getting the attention of consumers, but not on a menu.

Experimental studies have also explored the effectiveness of health warning messages to increase awareness of harms and intentions to quit WTS. Two experimental studies focused only on testing the message content rather than the delivery method or placement on tobacco package. In a study by Lipkus et al., young adults that had never smoked waterpipe were split by susceptibility to future use and randomized to view messages about the harms and addictiveness of WTS (Lipkus et al., 2016). These messages were delivered as online slides and not associated with the waterpipe tobacco package or device. The study found that compared to the participants that were not susceptible to future WTS, susceptible participants had lower perceived risk about harms and addictiveness of WTS, were more willing to experiment with WTS and messages were more effective in decreasing this desire to experiment. The messages were not effective among non-susceptible participants. Another message-testing study also by Mays, Tercyak and Lipkus showed that messages about the harm of WTS to current users could increase perceptions of harm and addictiveness of WTS relative to cigarette smoking, as well desire to quit in young adults (Mays, Tercyak, et al., 2016). The messages of harm paired with messages of addiction had similar outcomes to harm-only message with no significant differences. Also, they proposed

that this mechanism for increased intention to quit smoking waterpipe was likely mediated by the increase in worry about harm and addiction of WTS.

Additionally, there have been two experimental studies that have tested the format and placement of messages. First, an online survey of college students in the United States examined the influence of the format (text versus graphic) of health warning messages and their placement on different parts of waterpipe device (Islam et al., 2016). Interestingly, the study found that there was no significant difference in level of awareness of the harms of WTS or intentions to quit smoking between the different message formats or placement of the message on the different locations on waterpipe device. Second, a study also surveyed college students in the United States used a discrete choice experiment of waterpipe lounge menus (Salloum, Maziak, et al., 2015). In this study, participants were presented with menus that had tobacco of different flavors, as well as information on nicotine content. Some of the menus also included a text-only health warning. Participants were found to be averse to the products that had higher nicotine content and likely to opt out of a purchase when exposed to a menu with a health warning label.

### 2.7.2 Public Education Campaigns

Historically, public education campaigns for tobacco products in mass media (e.g. ‘Truth’ or ‘Tips from Former Smokers’) have focused on cigarettes. Although many of the leading voices in tobacco control, such as the CDC, WHO, Truth Initiative and Campaign for Tobacco Free Kids, have developed factsheets, advisory notes and infographics on waterpipe use and health consequences, mass media efforts have largely focused on cigarettes. Being that waterpipe lounges are often located near college campuses in the US, many universities have promoted campus-based campaigns addressing the myths of waterpipe use and health consequences to their

student population. The literature on communication campaigns for waterpipe is almost non-existent as most in practice have not been formally evaluated and published in scholarly journals.

*ShishAware* appears to be one of the few published evaluation of a public campaign to raise awareness about the health risks of WTS (Mohammed Jawad, Abass, et al., 2015). It was a grass-roots, online public education campaign using social media sites such as Facebook, Twitter, and YouTube, as well as a general campaign website. As the campaign creators were community members (two medical students and a health professional) based in the United Kingdom (UK), the audience was primarily from the UK, but it reached a global online community. The *ShishAware* campaign had a strong following from 2011 to 2012 on each social media platform and lead to meaningful collaborations with local government, schools and media. It required minimal resources for maintenance, but due to the lack of funding, the campaign team was only able to conduct process and implementation evaluation of the campaign using standard social media metrics (the number of followers, the number of views, the number of likes/dislikes and number of comments). The campaign creators did not assess the effects of the messages on the various social media platforms on awareness, knowledge, attitudes or behavior (initiation or cessation of WTS) of the target audience. The UK has also had some success with government sponsored education campaigns. The Health and Wellbeing Board of London Borough of Barnet launched their own ‘Shisha Public Education Awareness Campaign’ in late 2016 (London Borough of Barnet Health Department, 2017). The campaign included advertisements at bus shelters, billboards in high-traffic areas and print material at clinics and pharmacies in the community. The campaign also made use of a Twitter and Facebook. The campaign reach was evaluated through telephone and online questionnaire of a non-representative sample of residents. Most the surveyed residents reported that they had seen the campaign and that they had

learned something new from the campaign. Additionally, among the respondents that indicated they were current waterpipe smokers, about 40 reported that they were going to cut down as a result of viewing the campaign messages.

In the United States, a similar grass-roots effort was undertaken by Wellshare International, a non-governmental organization in Minnesota working with refugee and immigrant communities (Wellshare International, 2013). Through the East African Smoke-Free program, Wellshare International launched the ‘Dangers of Hookah’ campaign in the Twin Cities. The bilingual campaign targeting Somali children, youth and adults employed social media, radio ads, billboards and transportation kiosks to deliver culturally appropriate health messages. Lastly, Sutfin et al. conducted an online experiment of health messages for cigarillos and waterpipe tobacco for a hypothetical point-of-sale communication campaign (Sutfin et al., 2017). The experiment tested eight different messages on waterpipe tobacco. The messages highlighted a harmful constituent in the waterpipe smoke, an unappealing product where that same constituent is also found and a website for more information. The text messages were placed over shocking graphic images and were intended for teens and young adults at the point-of-sale in gas station convenience stores. The messages on waterpipe tobacco compared to the control messages changed the belief of the addictiveness of WTS, but not for relative risk of perception of harm to health.

### 2.7.3 Interventions

The lack of published studies and the limitations of available data make it difficult to develop evidence-based cessation interventions for WTS. Though the number of published empirical studies evaluating the effectiveness of tobacco cessation interventions for hookah smoking is growing, it still is very small in comparison to cigarettes. One of the few U.S.-based

interventions was an individual, behavioral intervention of college students (Lipkus et al., 2011). Ninety-one participants were randomized to receive either general information about hookah smoking (control) or a combination of general and health-related information about hookah smoking (intervention) (Lipkus et al., 2011). At six-months post-intervention, 62% of the intervention group versus 33% in the control group reported abstinence from hookah smoking; however, the attrition rate was 23%. The intervention was also brief (self-guided 15-minute PowerPoint).

Internationally, there has been more research on WTS interventions. A randomized control trial of behavioral support and pharmacological cessation intervention for WTS based in a health center in Pakistan was shown to be effective in increasing quit rates (Dogar et al., 2013). This highlighted the importance of addressing both the behavioral and biological components of addiction. Another intervention among Arab university students in Israel tested tailored health education in text and video format to increase knowledge of WTS and reduced use (Essa-Hadad et al., 2015). Participants in this study significantly reduced WTS one month post-intervention, and although they expressed high satisfaction with the intervention, there were no changes in knowledge of the harms of WTS. Another quasi-experimental intervention of male high schools in Iran compared mode of delivery for health education—digital media film versus a pamphlet (Shojaeifar et al., 2017). The knowledge, attitude, self-efficacy, and WTS preventive behavior improved in each condition, but was significantly different in the group exposed to the digital media. Finally, a more recent study conducted a brief intervention onsite at a waterpipe lounge in the U.S. (Leavens et al., 2018). Participants in this study were recruited as they entered the waterpipe lounge. All participants had their pre-CO level measured and were instructed to smoke normally. Those assigned to the experimental group were administered the intervention

following CO measurement. They were also told about their measurement levels and given personalized feedback. The control group completed the CO testing and post measures, but did not receive feedback on CO levels. The intervention resulted in an increase knowledge of WP-related harms, and importance of quitting WP smoking, and confidence in ability to quit WP smoking at post-WP session and at 3-months follow-up. However, at 3-months there was no difference between the groups in WP smoking behavior (days smoked).

## 2.8 Virtual Reality Applications in Health

Virtual reality (VR) is an interactive, three-dimensional, computer-generated environment where users are immersed in what feels like the real world. Instead of watching something on a screen, they are transported to a simulated setting (Parisi, 2015). VR allows users to experience everything around them in real-time and in a 360° environment with visual, auditory and sometimes haptic



*Figure 3. Virtual Reality Head Mounted Display*

feedback. VR applications are most commonly accessed through a head mounted display (HMD) that is connected to an external computer or video game console (Figure 3). Additional equipment, such as hand controllers, can be used to allow users to act upon the environment within the virtual world, such as grasping for objects. The technology has also developed to allow for 360° video of real life locations to be fed into the VR experience for greater authenticity.

Over the years, the use of VR has grown in the medical and healthcare setting. For example, the technology has been used to treat post-traumatic stress disorder in veterans (van 't Wout-Frank et al., 2019), anxiety disorders (Shiban, 2018) and phantom limb pain in amputees (Dunn et al., 2017), as well as to train health care professionals in surgical procedures (Bernardo, 2017). VR has also been used to assess nicotine addiction and assist in tobacco cessation. In a study by Carter et al., smokers experienced to VR worlds with and without cigarette cues and rated their cravings to better understanding the different triggers to smoking (Carter et al., 2008).

VR is a powerful tool to advance social and behavioral laboratory research methods in ways not previously possible. Participants can be immersed in a variety of scenarios to better understand, predict and change behavior (Persky & McBride, 2009). Traditionally, in social and behavioral research, there is a recognized tradeoff between an experimental environment that controls extraneous variables (internal validity) and how much that experimental environment is like the real world (external validity)—such that the more researchers control an experimental environment, the less generalizable it is to the real world. VR provides a solution to this balance by allowing researchers to create well-controlled, yet realistic environments for experiments; thus, better balancing internal and external validity.

VR is also emerging as a promising tool for public health communication research and practice. Several tobacco-related intervention studies have used virtual retail stores to measure knowledge, attitudes and behaviors (Dutra et al., 2018; Kim et al., 2013, 2014; Nonnemaker et al., 2018). Virtual stores provide a more real-life experience to test changes in the environment than traditional “static images” and are more feasible to test concepts or manipulations than in a real-world setting (Dutra et al., 2018). Exposure to health messages in virtual environments may elicit changes in attitudes and behaviors. One study examining the persuasive effects of anti-

alcohol messages in VR video game found that the more immersed users were in the VR environment, the less they were able to argue against the health message and the more their attitudes were changed about driving under the influence (Burrows & Blanton, 2016). Another study compared anti-smoking messages embedded in the VR environment compared to those shared on a two-dimensional, flat screen found that those exposed to messages in the VR environment had greater intention to share anti-smoking messages (Lee et al., 2018). There is a paucity research on application of VR to WTS.

## **2.9 Eye Tracking in Tobacco Regulatory Science**

Eye tracking has been used as a method in several studies to assess consumer attention to tobacco-related communication and marketing (Kaufman et al., 2018; Meernik et al., 2016). As a direct measure of attention, eye tracking reduces the bias that may exist with self-reported measures such as recall bias. Eye tracking metrics have been used to understand message attributes that draw viewers' attention or are difficult to process, as well message features that are related to behavioral outcomes (Pieters & Wedel, 2008). A commonly used eye tracking outcome measure is dwell time, which refers to the total time spent fixating on an area of interest (AOI) or visual stimulus (Pieters & Wedel, 2008). Dwell time is a valid indicator of attention and cognitive processing (Christianson et al., 1991; Fox et al., 1998). Another common metric is a fixation, which describes moments when the eyes of a viewer stop scanning and hold the central vision in a place to take in detailed information about the stimuli (Pieters & Wedel, 2008). A fixation can be described by the time to first fixation or the total number of fixations. Higher fixations on a visual stimulus are associated with better engagement and cognitive processing (Wedel & Pieters, 2000).

A systematic review of eye tracking studies reporting outcomes related to tobacco regulation and communication found that the method has been used to evaluate health warnings, tobacco product packaging, tobacco advertising at the point of sale, and general tobacco communication (Meernik et al., 2016). The studies in this review demonstrated that viewing time of health warning messages were an important predictor of recall (Fischer et al., 1989; Klein et al., 2015; Strasser et al., 2012) and that graphic health warning messages increased attention compared to text-only health warnings (Klein et al., 2015; Strasser et al., 2012). It is important to note that much of this existing research on attention to warnings, packages and advertisements has focused on cigarettes.

There are limited studies that have examined non-cigarette tobacco products. Research by Nonnemaker et al. on adult little cigar and cigarillos users' attention to packaging and found the presence of price promotions reduced attention from health warning labels (Nonnemaker et al., 2018). The study also found that health warnings labels with highlighted backgrounds were associated with a greater recall and risk perceptions of smoking. The second study by Londeree et al. examined electronic cigarette advertisements and showed greater attention to flavored (versus unflavored) products (Londerée et al., 2018). The study also revealed an association between attention to advertisement with greater willingness to try flavored (versus unflavored) electronic cigarettes. Further research is needed on the attention to advertisement and health messages on packaging for non-cigarette tobacco products, such as cigars, e-cigarettes and waterpipe, especially among vulnerable youth and young adults.

## Chapter 3: Methods

### 3 Study Overview and Design

This research explored how to effectively communicate information on WTS to young adults through two experimental studies, utilizing two unique populations. The first phase (Study 1) was a population-based survey experiment using the online platform, Amazon Mechanical Turk. Study 1 utilized a 2x2 factorial design to assess the individual and combined effects of a health warning message and nicotine content on waterpipe lounge menus on intention to quit smoking, as well as perception of relative harm, risk of health consequences and relative addiction (Aim 1). The major independent variables or ‘factors’ in the design included the health warning message (presence or absence) and nicotine content (presence or absence) on the waterpipe lounge menus (Figure 4). Online participants were randomized to one of four groups and completed a series of post-test only questionnaires (Figure 5).

The second study in this dissertation (Study 2), was a laboratory-based virtual reality experiment using a university community sample. Study 2 utilized a two-group, posttest-only, experimental design (Figure 6) to evaluate the effect of health-related information (health warning message + nicotine content) on waterpipe lounge menus on intention to quit smoking, as well as perception of relative harm, risk of health consequences and relative addiction through a virtual reality environment (Aim 2). Additionally, the virtual reality experiment examined the visual attention of participants to different content on the waterpipe lounge menu through eye tracking (Aim 3). Overall, the purpose of this research was to address the research priorities related to the regulatory authority of the FDA/CTP by examining how to communicate the health effects of non-cigarette tobacco products. Additionally, this study contributes to understanding

how technology applications may be used to address tobacco use prevention and control research, as well as the value of virtual reality in social behavioral research.

		Nicotine Level Message Content (NC)	
		+	-
Health Warning Message Content (HW)	+	Group 1	Group 2
	-	Group 3	Group 4

*Figure 4.* 2x2 Experimental design (Study 1) with ‘health warning message’ and ‘nicotine content’ as factors.

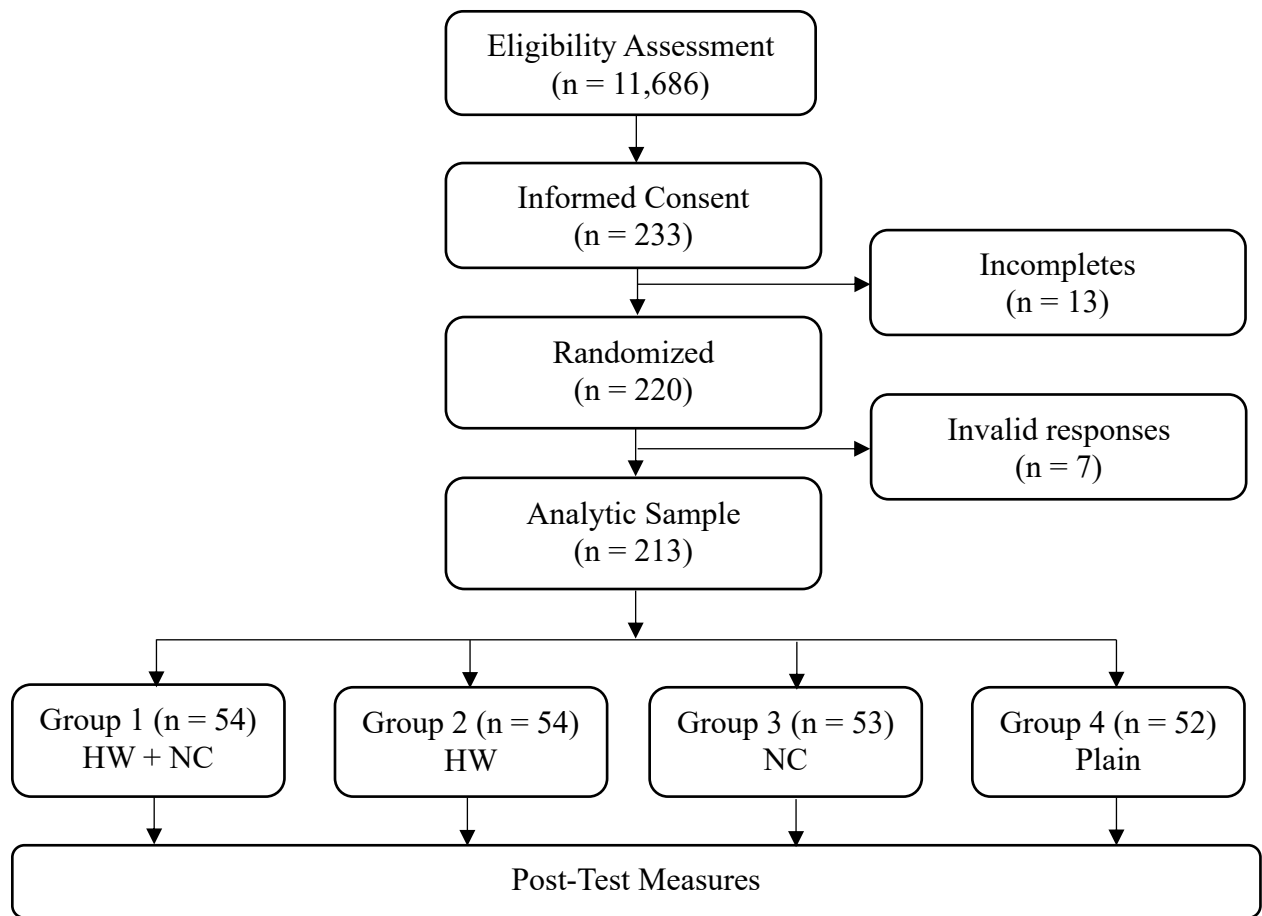


Figure 5. Consort Diagram, 2x2, post-test only, experimental design (Study 1).

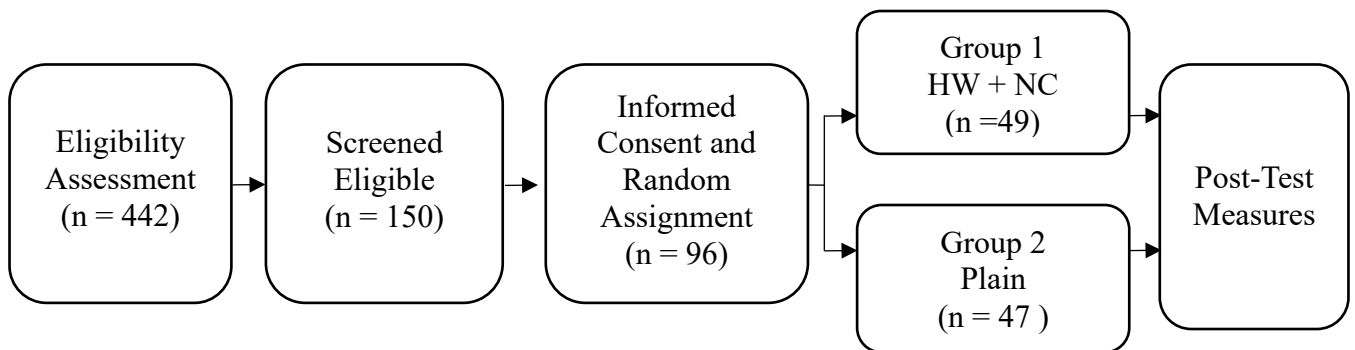


Figure 6. Consort Diagram, two group, post-test only, randomized design (Study 2).

## **3.2 Study 1: Online Testing of Waterpipe Lounge Menus**

### **3.2.2 Description of Population Studied**

For Study 1, the sample population was drawn from the online, crowdsourcing platform Amazon Mechanical Turk (AMT). The platform employs individuals from across the world to complete online human intelligence tasks, also known as HITs (Amazon, n.d.). The HITs are tasks, such as surveys, that require human responses or normally could not be completed as effectively using artificial (computer) intelligence (Amazon, n.d.). Over the past few years, AMT has grown in popularity by researchers in the social sciences to recruit larger, diverse samples for survey data collection and online experiments at a low cost and in a short period of time (Sheehan & Pittman, 2016). The AMT population is fluid and changes overtime, so much of the documented demographic data is cross-sectional or snapshots of the population (Ipeirotis, 2010). However, a longitudinal study of the demographics of the AMT population supports idea that most the AMT “workers” come from the United States and are millennials (born after 1990) (Difallah et al., 2018). In fact, over half of the AMT population surveyed during the 28-month study period were between 21 to 35 years of age.

Though there have been concerns from scholars regarding the data quality and the generalizability (or external validity) of the AMT population to general population (of the United States), studies support that the data collected using the AMT population is comparable in quality to the data collected using undergraduate students or professional survey panels in the United States (Casler et al., 2013; Kees et al., 2017). Additionally, there seems to be consensus in the research community of the value of AMT population as several tobacco-related studies (including waterpipe) have utilized the AMT population for research (Akbar et al., 2018; Jo et

al., 2018; P. S. Johnson et al., 2015; Mays, Tercyak, et al., 2016; Nicksic et al., 2017; Scott-Sheldon & Stroud, 2018).

### 3.2.3 Description of Sampling Procedure

A nonprobability, convenience sample of young adults were recruited for the online survey experiment through AMT. The study eligibility screener survey was posted as a single HIT through the AMT website and available for all registered AMT participants. Eligible participants were adults 18 to 24 years of age, resided in United States, smoked waterpipe some days or every day for at least one year and able to speak, read and write English. Additionally, the screener contained ‘attention check questions’ to screen out inattentive responses and ensure better data quality (Peer et al., 2014). Approximately 11,686 AMT participants completed the initial online survey screener from which 233 were screened as eligible and completed the online informed consent (Figure 5). The final analytic sample of participants randomized to groups with complete and valid data was 213. Attrition ( $n = 20$ ) was due to participants that withdrew after informed consent or during the post-test measures. Additionally, upon inspection of the data and AMT identification numbers duplicate responses were removed from the dataset.

### 3.2.4 Designation of Validity and Reliability of Instruments

In an effort to harmonize data collection efforts with other research and strengthen the evidence-base in the field of tobacco-risk communication, Study 1 utilized standardized questions and instruments as study measures. These measures have either undergone psychometric validation, have been used by published tobacco studies or are consistent with national surveys of tobacco use behaviors. Participants completed a series of four questionnaires:

WTS Experimental Study Questionnaire, Tobacco Use History Questionnaire, Lebanon Waterpipe Dependence Scale and Demography Questionnaire. The specific measures (or variables) used for Study 1 analyses are described below.

#### 3.2.4.1 *Primary Dependent Measure – Intention to Quit Smoking*

Intention to quit smoking was assessed among young adults by the following statement/question: “I intend to reduce or stop smoking hookah in the next 3 months.” The response option used a 5-point Likert scale from *strongly disagree* (1) to *strongly agree* (5). This statement was adapted from previous tobacco studies on cigarette smoking and has undergone psychometric testing for validity or reliability among cigarette smokers (Hummel et al., 2018; Popova & Ling, 2013a).

#### 3.2.4.2 *Secondary Dependent Measures – Perceived Relative Harm, Perceived Risk of Health Consequences and Perceived Relative Addiction*

Perceived harm to health was assessed using an indirect and direct measure of relative harm (Popova & Ling, 2013b). The indirect measure of relative harm consisted of two questions: “In your opinion, how harmful is hookah smoking to general health?” and “In your opinion, how harmful is smoking cigarettes for health?” Response options for both items used a 7-point Likert scale from *not at all harmful* (1) to *extremely harmful* (7). The mean difference between these two items were used to calculate an indirect measure of relative harm of WTS. The direct measure of relative harm consisted of one question: “Compared to smoking cigarettes, how harmful is smoking hookah?” The response options used a 5-point Likert scale from *much more harmful* (1) to *much less harmful* (5).

Perceived addiction was assessed using an indirect and direct measure of relative addiction (Popova & Ling, 2013b). The indirect measure of relative addiction consisted of two questions: “In your opinion, how addictive is hookah smoking to general health?” and “In your opinion, how addictive is smoking cigarettes for health?” Response options for both items used a 7-point Likert scale from *not at all addictive* (1) to *extremely addictive* (7). The mean difference between these two items was used to calculate an indirect measure of relative addiction of WTS. The direct measure of relative addiction consisted of one question: “Compared to smoking cigarettes, how addictive is smoking hookah?” The response options used a 5-point Likert scale from *much more addictive* (1) to *much less addictive* (5).

These six items (the indirect and direct measure of relative harm and the indirect and direct measure of relative addiction) were adapted from a survey used in a national study examining alternative tobacco products (smokeless tobacco and electronic cigarettes) and smoking cessation, and they have not undergone specific psychometric testing for validity or reliability (Popova & Ling, 2013b). Indirect and direct measures of relative harm or risk are known to produce varying responses for the same product comparisons. However, the study by Popova and Ling (2013) demonstrated that indirect items are more accurate measures of the underlying difference in perceptions of harm or risk. Thus, the basis for the hypotheses outlined in this dissertation and the analysis used the indirect measures of relative harm and addiction.

Perceived risk of health consequences was assessed using three questions: “What are the chances that you might develop some type of cancer within your lifetime if you continue to smoke hookah?” “What are the chances that you might have a heart attack within your lifetime if you continue to smoke hookah?” and “What are the chances that you might decrease your lung function within your lifetime if you continue to smoke hookah?” Response options for the three

items used a 7-point Likert scale from *very low/not likely* (1) to *very high/likely* (7). The measures of perceived health risk were adapted from work by (Magnan, 2017) and shown to have alpha reliability of 0.93 in past research.

#### 3.2.4.3 *Demographic Variables*

- Gender—defined as male, female, transgender male or transgender female
- Race/Ethnic Origin—defined White, Latino, Black, Hispanic, Native American or Asian/Pacific Islander
- Education- Defined as some high school, high school graduate, some college, trade/technical/vocational training, college graduate, some postgraduate work or post graduate degree

#### 3.2.4.4 *Waterpipe Tobacco Smoking Dependence*

The Lebanon Waterpipe Dependence Scale (LWDS-11) consists of 11 items using a 4-point Likert response scale (Pascale Salameh et al., 2008). The score is based on the sum of the four subscale scores: physiological nicotine dependence, negative reinforcement, psychological craving and positive reinforcement. The LWDS instrument has undergone specific psychometric testing. It has demonstrated strong internal consistency ( $\alpha=0.83$ ) and test-retest reliability ( $r = 0.92$ ) (Pascale Salameh et al., 2008). The complete scale can be found in Appendix A.

#### 3.2.4.5 *Other Tobacco Product Use*

The listed questions were drawn from Population Assessment of Tobacco and Health Study to determine a respondent's tobacco product use and regularity of use (Center for Tobacco

Products, n.d.). The PATH study uses standard measures of tobacco use behaviors that have undergone cognitive testing and are used in most data collection efforts for tobacco studies.

- Ever Use of Cigarettes—Have you ever smoked a cigarette, even just one puff?
- Current Use of Cigarettes—Do you currently smoke cigarettes every day, some days or not at all?
- Frequency of Cigarette Use—How long (years) have you been smoking cigarettes regularly?
- Ever Use of Cigar Products—Have you ever smoked cigars or cigarillos, or little cigars?
- Current Use of Cigar Products—Do you currently smoke cigars or cigarillos, or little cigars every day, some days, or not at all?
- Frequency of Cigar Product Use—How long (years) have you been smoking cigars or cigarillos, or little cigars regularly?
- Ever Use of E-Cigarettes—Have you ever used an e-cigarette or vaping device?
- Current Use of E-Cigarettes—Do you currently use e-cigarettes or vaping devices every day, some days, or not at all?
- Frequency of E-Cigarette Use—How long (years) have you been using e-cigarettes or vaping devices regularly?

### 3.2.5 Procedural Outline of Steps Followed

#### 3.2.5.1 *Waterpipe Lounge Menus*

The menu format and content were developed by reviewing a number of sample menus from websites of waterpipe lounges, as well as brands of waterpipe tobacco packaging. The

health warning message was tailored from the Surgeon General's Warning for cigarettes and the FDA required warning message for non-cigarette tobacco products. The nicotine levels were based on the common values advertised on current waterpipe tobacco packaging. The four menus are provided in Appendix B.

### 3.2.5.2 *Human Subjects Procedures*

Research activities for human participants were approved by University of Maryland Institutional Review Board (Appendix C) in March 2018 and renewed in March 2020. Participants were recruited through Amazon Mechanical Turk for data collection from June 2018 to August 2018. A brief description of the study and link to the eligibility screener was posted as an HIT for interested Amazon Mechanical Turk participants. Researchers administered the online experiment through the Qualtrics Survey Software provided to all University of Maryland faculty, students and staff. Following the screener, eligible participants were directed to the complete study description and online consent form. Eligible, consenting participants continued immediately to the online experiment. Using an algorithm embedded in the online survey, participants were randomized in equal numbers to view one of four menus and complete the posttest questionnaires. Following the posttest assessment, participants were given a list of online resources for WTS education and cessation from the CDC and other governmental organizations. Participants completing all study procedures were given a monetary payment through Amazon Mechanical Turk. The complete procedural steps for data collection are described in Table 1. All data collection and data storage was managed by the University of Maryland Qualtrics Survey Software (versus the public Qualtrics website or Amazon Mechanical Turk).

**Table 1**  
**Study 1 IRB Approved Protocol**

Time	Task	Description
2 minutes	Screener Survey	Participants were screened online through a series of eligibility questions, and those that passed the screener survey were directed to web link provide consent to complete the online experiment.
5 minutes	Informed Consent	A statement of consent was presented before the online experiment at which point participants selected if they agree to participate or do not agree to participate in the online experiment.
20+ seconds	Randomization to Group and Exposure to Menu	Participants viewed one of four lounge menus for a minimum time of 20 seconds before being allowed to advance the survey screen.  Group 1: Health Warning Message + Nicotine Content Group 2: Health Warning Message + No Nicotine Content Group 3: No Health Warning Message + Nicotine Content Group 4: No Health Warning Message + No Nicotine Content
15 minutes	Post-Exposure Questionnaires	WTS Experimental Study Questionnaire Tobacco Use History Questionnaire Lebanon Waterpipe Dependence Scale Demography Questionnaire
Study Debrief		Participants were provided information on tobacco cessation resources.
Study Compensation		Participants were provided an Amazon Mechanical Turk completion code to received \$2 for time and effort.

### 3.2.6 Data Analysis

Statistical analyses were run using the IBM SPSS® software platform. Descriptive statistics were completed to examine the Study 1 dataset and characterize the AMT study sample. Percentages were calculated for categorical variables, and means and standard deviations for continuous variables. Participant characteristics (such as demographics, other tobacco product use and waterpipe dependence) were examined for any potential differences between the groups. Bivariate analyses confirmed no difference ( $p < 0.05$ ) in participant traits by

group/condition. Also, tested relationship between participant traits (demographics, other health use, LWDS score, age of initiation of WTS) and the different DVs. These potential covariates were not related to the different DVs ( $p < 0.05$ ), and thus, not included in the analysis. There were no patterns identified for missing data (incomplete questions). For analysis of Aim 1 hypotheses, assumptions for parametric analysis (two-way ANOVA) were checked including normality, linearity, and equality of variance. However, all DVs were found to violate the assumption of normality, so non-parametric tests were required for analysis of group differences. Because the two-way ANOVA was not possible, only the differences between the four groups, as well as within each of the proposed factors (as two groups) were examined and not interactions of the two factors. First, the Kruskal-Wallis H Test was used to assess differences in median values between the four groups/conditions (Groups 1, 2, 3 and 4). For all Kruskal-Wallis tests, the observed  $H$ -value, degrees of freedom (df), mean, standard deviation and significance level are reported. Second, the Mann-Whitney U Test was used to assess differences between two independent groups: health warning (Group 1 and 2) versus no health warning (Group 3 and 4) and nicotine content (Group 1 and 3) versus no nicotine content (Group 2 and 4). For all Mann-Whitney tests, the results report the U statistic, z-score, mean, standard deviation and significance level.

### **3.3 Study 2: Virtual Reality Testing of Waterpipe Lounge Menus**

#### **3.3.2 Description of Population Studied**

For Study 2, the sample population was drawn from the University of Maryland (UMD) student population. UMD is a public, co-educational, academic institution and the largest in the state of Maryland, as well the Metropolitan Washington Area. In the Fall of 2018, student enrollment was 30,762 for undergraduate students and 10,438 for graduate students (Office of Institutional Research, Planning and Assessment, 2018). The student population includes a diverse racial background (46.2% White, 14.6% Asian, 10.6% Black/African-American, 8.2% Hispanic/Latino and 20.4% other). Regarding the campus culture of tobacco use, the university implemented a tobacco-free policy in 2013, which includes WTS; however, compliance with the policy or enforcement is not consistent among students, staff and faculty. Additionally, there are multiple waterpipe lounges and tobacco retail stores that sell waterpipe tobacco within the campus neighborhood. Data from the 2014 National College Health Assessment survey estimates that ever use of waterpipe tobacco among the UMD undergraduate student population was 27.5% and current use in the past 30 days was 8.2% (American College Health Association, 2014). These campus-specific figures have likely increased over the past four years, in line with national surveillance data on tobacco use.

#### **3.3.3 Description of Sampling Procedure**

A nonprobability, convenience sample of young adults was recruited from the student population at the UMD through print and digital advertisements. Print advertisements were distributed on campus bulletins and bus shelters, as well as the nearby housing communities, waterpipe lounges and tobacco retailers. Digital advertisements were posted on social media and

shared through emails listservs to campus student organizations. Eligible participants that saw advertisement and were interested in the study were directed to an online survey screener on Qualtrics. Following the screener, those eligible were asked to provide contact information and schedule availability. Eligible participants were adults 18 to 24 years of age, resided in Washington Metropolitan Area, smoked waterpipe some days or every day for at least one year and able to speak, read, and write English. Additionally, they were required to travel to School of Public Health for the one-hour laboratory session. Participants were contacted through email or phone to setup the study visit.

### 3.3.4 Designation of Validity and Reliability of Instruments

In addition to the measures used for data collection for Study 1, Study 2 collected eye tracking data to examine the attention of participants on the waterpipe lounge menu during the VR experience. The eye-tracker, integrated in the FOVE VR headset, was calibrated for precision and accuracy for each participant to provide a direct (objective) measure of eye moments. This insured the measurements properly tracked eye moments. The specific measures (or variables) unique to the Study 2 analyses are described below.

#### 3.3.4.1 Secondary Dependent Measures –Fixation Count, Dwell Time

Fixation and dwell measurements were completed by the FOVE eye-tracker. The fixation count (the number of fixations) looks for periods of time when the focus of the participant's gaze is relatively still on an area in the VR experience. The dwell time is the duration spent viewing an area in the VR experience.

### 3.3.5 Procedural Outline of Steps Followed

#### 3.3.5.1 *Waterpipe Lounge Menus*

Study 2 utilized two of the four menus described in Study 1: menu 1 and menu 4. Participants in the experimental group (Group 1) viewed waterpipe lounge menu 1 with combined health information (health warning and nicotine content). Participants in the control group (Group 2) viewed waterpipe lounge menu 4 with a health information. The menus are provided in Appendix B.

#### 3.3.5.2 *Virtual Reality Immersive Film and Equipment*

For the virtual reality experience in Study 2, immersive 360° video and sound were filmed at a real life waterpipe lounge. A nonmonetary memorandum of understanding (MOU) was established between UMD and the waterpipe lounge to film at the location during business hours. Student volunteers, that self-identified as regular waterpipe smokers, were recruited to serve as the actors in VR experience. The volunteers were compensated for their time and travel, as well as the items purchased for consumption during the filming. During filming, an Insta360 PRO spherical VR camera was mounted on a tripod and positioned as a “seat” at the table with the actors smoking waterpipe to simulate participation in the group setting. Thus, the participant (viewer) was at the center of the video scene and experienced a complete 360° panoramic view of the lounge. The film followed three scenes: introduction of the group, viewing the menu and smoking waterpipe tobacco (Figure 7). At the time of “exposure,” the waterpipe lounge menu was positioned in front of the camera to simulate viewing by the participant.



*Figure 7. Waterpipe Lounge Virtual Reality Scenes: introduction of the group, viewing the menu and smoking waterpipe tobacco.*

All film footage was stitched together and processed by a computer programmer at the *University of Maryland Institute for Advanced Computer Studies (UMIACS)* before viewing with the FOVE virtual reality system. The FOVE is the first virtual reality headset to utilize eye tracking. The immersive video is a recorded 360° video that was mapped onto a sphere around the observer. Before viewing the immersive video, participants ran through a software calibration process to calibrate their eyes (gaze) to the FOVE headset. The eye tracking data outputs coordinates on the sphere. For the calibration procedure, the participants put on the VR head set and viewed a blank screen. They were instructed to fixate their eyes on a green dot and follow the dot as it moved and grew on the screen. The eye tracker measured the characteristics of the participant's eyes and used these measurements (along with an anatomical eye model) to calculate the "gaze" or where they are looking in the immersive video.

**Table 2*****Study 2 IRB Approved Protocol***

<b>Time</b>	<b>Task</b>	<b>Description</b>
5 min	Screening Questionnaire	Participants were screened online through a series of eligibility questions. They received a follow-up email or phone call to schedule a laboratory visit.
15 min	Informed Consent	Participants were given a presentation of the study purpose and procedures. There was a written informed consent form that follows the standard University of Maryland IRB informed consent template.
5 min	VR Eye Calibration	While wearing the FOVE VR headset, participants were instructed to look (at a green dot) in different directions until the system has a lock on the eyes.
6 min	Randomization to Film Group and Exposure to Menu	Participants viewed 360° film and sound of young adults smoking in a waterpipe lounge with exposure to one of two possible menus.  Group 1: Health Warning Message + Nicotine Content Group 2: No Health Warning Message + No Nicotine Content
20 min	Post-Exposure Questionnaires	WTS Experimental Study Questionnaire Tobacco Use History Questionnaire Lebanon Waterpipe Dependence Scale Demography Questionnaire Virtual Reality User Experience
Study Debrief		Participants were provided information on tobacco cessation resources.
Study Compensation		Participants were provided \$25 for their time, effort and travel.

**3.3.5.3 Human Subjects Procedures**

Research activities for human participants were initially approved by University of Maryland Institutional Review Board (Appendix C) in March 2018 and renewed/approved in February 2020. Data collection began in October 2018 and 96 participants were processed by May of 2019 (sample size as set by timeline and funding availability). Eligible participants were scheduled for an in-person laboratory visit at the School of Public Health. During the visit

participants provided written consent for participation and were randomized to view one of two immersive virtual reality videos and complete posttest questionnaires. The two immersive virtual reality videos were identical except for the “menu exposure” scene, which uses two of the four menus described in Study 1. Following the posttest assessment, participants were given a list of online resources for WTS education and cessation. Participants completing all study procedures were compensated \$25 for their time, effort and travel. The complete procedural steps for data collection are described in Table 2. Survey data collection and data storage was managed by the University of Maryland Qualtrics Survey Software. Eye tracking data was collected and stored on a computer used to run the FOVE virtual reality system.

### 3.3.6 Proposed Data Analysis

Statistical analyses was run using the IBM SPSS® software platform. Descriptive statistics were completed to examine the Study 2 dataset and characterize the lab study sample. Percentages were calculated for categorical variables, and means and standard deviations for continuous variables. Participant characteristics (such as demographics, other tobacco product use and waterpipe dependence) were examined for any potential differences between the groups. Bivariate analyses confirmed no difference ( $p < 0.05$ ) in participant traits by group/condition. Also, tested relationship between participant traits (demographics, other health use, LWDS score, age of initiation of WTS) and the different DVs. These potential covariates were not related to the different DVs ( $p < 0.05$ ), and thus, not included in the analysis. There were no patterns identified for missing data (incomplete questions) for the survey measures.

Data validation for the eye tracking metrics were verified through an autodetection program in excel for impossible values. As previously described the immersive 360° video was

mapped onto a sphere around the observer, and the eye tracking data outputs coordinates on the

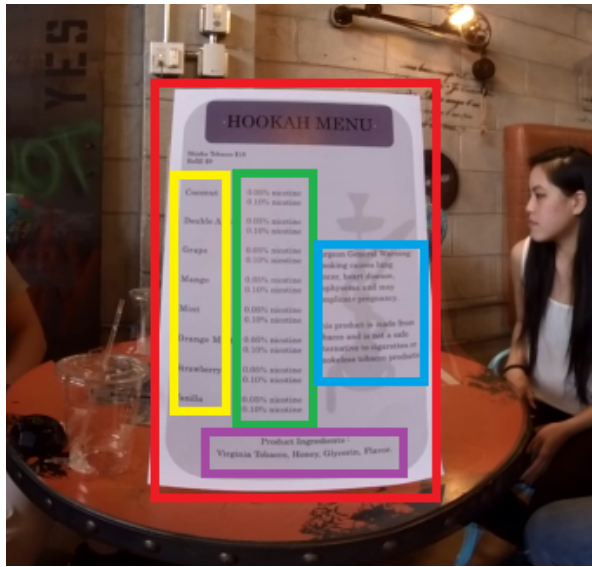


Figure 8. Waterpipe Lounge Menu AOIs: flavor (yellow), nicotine content (green), health warning message (blue) and ingredient list (purple).

sphere. A program was created to process the eye tracking data into the needed metrics for analyses. The waterpipe lounge menus had four defined areas of interests (AOIs): flavor, nicotine content, health warning message, and ingredients (Figure 8). The AOIs were defined the same for the experimental and control condition even when no content was present in that area of the menu. This allowed for examination of how much attention a participant would give to an

AOI when content is present (*Avoidance of Cigarette Pack Health Warnings among Regular Cigarette Smokers*, n.d.). Additionally, the boundaries of the AOIs were not visible to the participants viewing the immersive video. Visual attention to each AOI was described by two values: fixation count and dwell time.

For analysis of Aim 2 and Aim 3 hypotheses, assumptions for parametric analysis (independent samples t-tests) were checked including normality, linearity, and equality of variance. However, all DVs were found to violate the assumption of normality, so non-parametric tests were required for analysis of group differences. Mann-Whitney U Test was used to assess differences in median values between the treatment and control groups. For results, the U statistic and z-score are reported along with the mean, standard deviation and significance level.

## Chapter 4: Results

### 4.1 Study 1 AMT Sample and Characteristic

Overall, 11,686 AMT participants responded to the screening questionnaire, 233 of whom were deemed eligible to enroll in the study and 220 of whom were randomized into one of the four experimental conditions and completed post-test measures. The main reasons for ineligibility were ‘not a regular hookah smoker’ and ‘older than 24 years of age.’ The final analytical sample was composed of 213 participants due to removal of duplicate entries (potentially falsified responses) as noted by the similar AMT identification numbers. The study sample averaged 22.48 (SD = 1.90) years of age, were majority White (65.6%), often college-educated (42.3%) and relatively even with respect to gender (54.5% male vs. 45.5% female). Most reported mild use (86.4%) of waterpipe defined as smoking three waterpipes or less per week. Overall, 63 participants (29.57%) were waterpipe only users, 150 participants were dual (39%) or poly (31.5%) tobacco users. Among the dual and poly users, 86 participants (40.4%) were current cigarette smokers. Table 3 (Appendix D) provides a summary of participant demographic and tobacco use characteristic for the overall sample and by experimental condition. There were no significant differences in participant characteristics across groups.

### 4.2 Aim 1 Overall Significant Outcomes

*Aim 1: Assess the effects of a health warning message and nicotine content on waterpipe lounge menus on intention to quit smoking, as well as the perceptions of relative harm, risk of health consequences and relative addiction among young adult waterpipe tobacco smokers.*

The results for Aim 1 group differences between the four menus (or experimental

conditions) for intention to quit smoking, perceived indirect relative harm, perceived risk of health consequences (cancer, heart attack and decreased lung function), and perceived indirect relative addiction are shown in Table 4 (Appendix E). For these outcomes, there was a statistically significant difference between groups for perceived indirect relative harm ( $H(3) = 8.39, p = 0.04$ ), as well as perceived risk of heart attack ( $H(3) = 14.30, p = 0.00$ ) and perceived risk of decreased lung function ( $H(3) = 10.44, p = 0.02$ ). The results for Aim 1 group differences by presence or absence of a health warning message on menus for intention to quit smoking, perceived indirect relative harm, perceived risk of health consequences (cancer, heart attack and decreased lung function), and perceived indirect relative addiction are shown in Table 5 (Appendix F). For these outcomes, there was a statistically significant difference only for perceived risk of decreased lung function ( $U = 6.839, z = 2.67, p = 0.01$ ). The results for Aim 1 group differences by presence or absence of nicotine content on menus for intention to quit smoking, perceived indirect relative harm, perceived risk of health consequences (cancer, heart attack and lung function), and perceived indirect relative addiction are shown in Table 6 (Appendix G). For these outcomes, there was a statistically significant difference only for perceived risk of heart attack ( $U = 7,164.5, z = 3.37, p = 0.00$ ).

#### ***4.2.1 Primary Dependent Measure: Intention to Quit Smoking***

There was no effect of combined health information ( $p = 0.33$ ), a health warning message only ( $p = 0.45$ ) or nicotine content only ( $p = 0.43$ ) presented on waterpipe lounge menus on intention to quit smoking. Participants who were exposed to a waterpipe lounge menu with any of the manipulations (combined health information, health warning message or nicotine content) did not significantly differ on intention to quit smoking compared to participants who were exposed to a plain waterpipe lounge menu.

#### **4.2.2 Secondary Dependent Measure: Perceived (Indirect) Relative Harm**

There was a significant difference between the four experimental conditions on perceived relative harm of waterpipe tobacco smoking ( $p = 0.04$ ). Pairwise comparisons illustrated that participants that viewed a waterpipe lounge with a health warning message reported *greater perceived relative harm* of waterpipe tobacco smoking (mean [SD] 1.74 [1.56]) compared to participants that viewed a plain waterpipe lounge menu (mean [SD] 2.56 [1.54]). The comparison by health warning message ( $p = 0.09$ ) or nicotine content ( $p = 0.16$ ) groups did not present significant differences on perceived relative harm of waterpipe tobacco smoking.

#### **4.2.3 Secondary Dependent Measure: Perceived Risk of Health Consequences (Cancer)**

There was no effect of combined health information ( $p = 0.78$ ), a health warning message ( $p = 0.90$ ) or nicotine content ( $p = 0.82$ ) presented on waterpipe lounge menus on perceived risk of cancer from waterpipe tobacco smoking. Those that viewed a waterpipe lounge menu with combined health information, a health warning message or nicotine content *did not significantly differ* from those that viewed a plain waterpipe lounge menu on perceived risk of cancer from waterpipe tobacco smoking.

#### **4.2.4 Secondary Dependent Measure: Perceived Risk of Health Consequences (Heart Attack)**

There was an effect of combined health information (health warning message and nicotine content) presented on waterpipe lounge menus on perceived risk of heart attack from waterpipe tobacco smoking ( $p = 0.00$ ). Pairwise comparisons illustrated that participants that viewed a waterpipe lounge menu with combined health information (mean [SD] 4.22 [1.76]) or

only nicotine content (mean [SD] 4.30 [3.23]) reported *greater perceived risk of heart attack* from waterpipe tobacco smoking compared to participants that viewed a plain waterpipe lounge menu (mean [SD] 3.23 [1.40]).

Additionally, there was no effect of a health warning message presented on waterpipe lounge menus on perceived risk of heart attack from waterpipe tobacco smoking among young adults ( $p = 0.34$ ). However, there was an effect of nicotine content ( $p = 0.00$ ) presented on waterpipe lounge menus on perceived risk of heart attack from waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu with nicotine content reported *greater perceived risk of heart attack* from waterpipe tobacco smoking (mean [SD] 4.26 [1.70]) compared to participants that viewed a waterpipe lounge without nicotine content (mean [SD] 3.50 [1.49]).

#### ***4.2.5 Secondary Dependent Measure: Perceived Risk of Health Consequences (Lung Function)***

There was an effect of combined health information (health warning and nicotine content) presented on waterpipe lounge menus on perceived risk of decreased lung function from waterpipe tobacco smoking among young adults ( $p = 0.02$ ). Pairwise comparisons illustrated that participants that viewed a waterpipe lounge menu with combined health information reported *greater perceived risk of decreased lung function* from waterpipe tobacco smoking (mean [SD] 5.50 [1.31]) compared to participants that viewed a plain waterpipe lounge (mean [SD] 4.58 [1.65]).

Additionally, there was an effect of a health warning message ( $p = 0.01$ ) presented on waterpipe lounge menus on perceived risk of decreased lung function from waterpipe tobacco

smoking. Participants that viewed a waterpipe lounge menu with a health warning message reported *greater* perceived risk of decreased lung function from waterpipe tobacco smoking (mean [SD] 5.50 [1.31]) compared to participants that viewed a waterpipe lounge without a health warning message (mean [SD] 5.46 [1.26]).

However, there was no effect of a nicotine content presented on waterpipe lounge menus on perceived risk of decreased lung function from waterpipe tobacco smoking among young adults ( $p = 0.13$ ). Those that viewed a waterpipe lounge menu with nicotine content *did not significantly differ* from those that viewed a plain waterpipe lounge menu on perceived risk of decreased lung function from waterpipe tobacco smoking.

#### ***4.2.6 Secondary Dependent Measure: Perceived (Indirect) Relative Addiction***

There was no effect of combined health information ( $p = 0.06$ ), a health warning message ( $p = 0.10$ ) or nicotine content ( $p = 0.28$ ) presented on waterpipe lounge menus on perceived relative addiction of waterpipe tobacco smoking. Participants who were exposed to waterpipe lounge menu with any of the manipulations (combined health information, health warning message or nicotine content) *did not significantly differ* on perceived relative addiction of waterpipe tobacco smoking compared to participants who were exposed to a plain waterpipe lounge menu.

### **4.3 Study 2 VR Laboratory Sample and Characteristic**

All participants for Study 2 were current undergraduate or graduate students at the UMD. Overall, 442 participants responded to the online screening questionnaire, 150 of whom were deemed eligible to enroll in the study and 96 of whom were randomized into one of two experimental conditions in the VR laboratory and completed post-test measures. As with the Study 1 AMT sample, the main reasons for ineligibility were ‘not a regular hookah smoker’ and ‘older than 24 years of age.’ The study sample averaged 21.11 (SD = 1.72) years of age, represented diverse racial backgrounds (22.92% White, 29.17% Black and 27.08% Latinx) and was relatively even with respect to gender (52% male). A majority reported mild use of waterpipe (86.5%), defined as smoking three waterpipes or less per week. Overall, 55 participants (57.37%) were waterpipe only users, 41 participants were dual or poly tobacco users (42.7%). Among the dual and poly users, 20 participants (20.8%) were current cigarette smokers. Table 7 (Appendix H) provides a summary of participant demographic and tobacco use characteristic for the overall VR laboratory sample and by experimental condition. There were no significant differences in participant characteristics between the two groups.

### **4.4 Aim 2 Overall Significant Outcomes**

*Aim 2: Evaluate the effect of health information on waterpipe lounge menus on intention to quit smoking, as well as the perceptions of relative harm, risk of health consequences and relative addiction through a virtual reality environment.*

The results for Aim 2 group differences (experimental menu with health information versus the control menu with no health information) for intention to quit smoking, perceived

indirect relative harm, perceived risk of health consequences (cancer, heart attack and decreased lung function), and perceived indirect relative addiction are shown in Table 8 (Appendix I). For these outcomes, there was a statistically significant difference between groups for intention to quit smoking ( $U = 1,543, z = 2.99, p = 0.00$ ) and perceived risk of decreased lung function ( $U = 1,458.5, z = 2.32, p = 0.02$ ).

#### **4.4.1 Primary Dependent Measure: Intention to Quit Smoking**

There was an effect of health information (health warning message and nicotine content) on waterpipe lounge menus on intention to quit smoking among young adults ( $p = 0.00$ ).

Participants that viewed a waterpipe lounge menu in VR with health information (health warning message and nicotine content) reported *greater* intention to quit smoking (mean [SD] 3.41 [0.93]) compared to participants that viewed a plain waterpipe lounge (mean [SD] 2.81 [0.99]).

#### **4.4.2 Secondary Dependent Measure: Perceived (Indirect) Relative Harm**

There was no effect of health information (health warning message and nicotine content) on waterpipe lounge menus on perceived relative harm of waterpipe tobacco smoking among young adults ( $p = 0.16$ ). Participants that viewed a waterpipe lounge menu in VR with health information *did not significantly differ* on perceived relative harm of waterpipe tobacco smoking compared to participants that viewed a plain waterpipe lounge menu.

#### **4.4.3 Secondary Dependent Measure: Perceived Risk of Health Consequences (Cancer)**

There was no effect of health information (health warning message and nicotine content) on waterpipe lounge menus on perceived risk of cancer from waterpipe tobacco smoking among young adults ( $p = 0.49$ ). Participants that viewed a waterpipe lounge menu in VR with health

information *did not significantly differ* on perceived risk of cancer from waterpipe tobacco smoking compared to participants that viewed a plain waterpipe lounge menu.

#### ***4.4.4 Secondary Dependent Measure: Perceived Risk of Health Consequences (Heart Attack)***

There was no effect of health information (health warning message and nicotine content) on waterpipe lounge menus on perceived risk of heart attack from waterpipe tobacco smoking among young adults ( $p = 0.42$ ). Participants that viewed a waterpipe lounge menu in VR with health information *did not significantly differ* on perceived risk of heart attack from waterpipe tobacco smoking compared to participants that viewed a plain waterpipe lounge menu.

#### ***4.4.5 Secondary Dependent Measure: Perceived Risk of Health Consequences (Lung Function)***

There was an effect of health information (health warning message and nicotine content) on waterpipe lounge menus on perceived risk of decreased lung function from waterpipe tobacco smoking among young adults ( $p = 0.02$ ). Participants that viewed a waterpipe lounge menu in VR with health information reported *greater* perceived risk of decreased lung function from waterpipe tobacco smoking (mean [SD] 5.78 [1.33] compared to participants that viewed a plain waterpipe lounge (mean [SD] 5.13 [1.48]).

#### ***4.4.6 Secondary Dependent Measure: Perceived (Indirect) Relative Addiction***

There was no effect of health information (health warning message and nicotine content) on waterpipe lounge menus on perceived relative addiction of waterpipe tobacco smoking among young adults. Participants that viewed a waterpipe lounge menu in VR with health information

did not significantly differ on perceived relative addiction of waterpipe tobacco smoking compared to participants that viewed a plain waterpipe lounge menu.

#### 4.5 **Aim 3 Overall Significant Outcomes**

*Aim 3: Examine visual attention to content on waterpipe lounge menus in a virtual reality (waterpipe lounge) environment using eye tracking data.*

The results for Aim 3 group differences (experimental menu with health information versus the control menu with no health information) for the eye tracking metrics are shown in Table 9 (Appendix J). For these outcomes, there was a statistically significant difference between groups fixations on the nicotine area of the menu ( $U = 1, 815, z = 5.64, p = 0.00$ ) and warning message area of the menu ( $U = 1, 795.5, z = 5.50, p = 0.00$ ). Also, there was a statistically significant difference between groups on dwell time for the overall menu ( $U = 1, 371, z = 2.28, p = 0.03$ ), flavor area of the menu ( $U = 731, z = -2.69, p = 0.01$ ), nicotine area of the menu ( $U = 1, 992, z = 7, p = 0.00$ ), the health warning message area of the menu ( $U = 2, 059, z = 7.52, p = 0.00$ ) and ingredient area of the menu ( $U = 824, z = -1.98, p = 0.05$ ).

##### 4.5.1 ***Secondary Dependent Measure: Fixation Count***

There was no effect of health information (health warning message and nicotine content) on waterpipe lounge menus on attention as measured by the number of fixations on the overall menu ( $p = 0.06$ ). Participants that viewed a waterpipe lounge menu in VR with health information looked at the menu *as often* as participants that viewed a plain waterpipe lounge menu without health information.

There was an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the number of fixations on the nicotine area of the menu ( $p = 0.00$ ). Participants that viewed a waterpipe lounge menu in VR with health information looked at the nicotine area of the menu *more often* (mean [SD] 33.07 [11.68]) compared to participants that viewed a plain waterpipe lounge menu (mean [SD] 18.81 [14.25]).

There was an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the number of fixations on the warning message area of the menu ( $p = 0.00$ ). Participants that viewed a waterpipe lounge menu in VR with health information looked at the warning message area of the menu *more often* (mean [SD] 17.09 [7.92]) compared to participants that viewed a plain waterpipe lounge menu (mean [SD] 9.26 [5.26]).

There was not an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the number of fixations on the flavor area of the menu ( $p = 0.39$ ). Participants that viewed a waterpipe lounge menu in VR with health information looked at the flavor area *as often* as participants that viewed a plain waterpipe lounge menu.

There was not an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the number of fixations on the ingredient area of the menu ( $p = 0.09$ ). Participants that viewed a waterpipe lounge menu in VR with health information looked at the ingredient area of the menu *as often* as participants that viewed a plain waterpipe lounge menu.

#### 4.5.2 *Secondary Dependent Measure: Dwell Time (seconds)*

There was an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the dwell time on the menu ( $p = 0.03$ ). Participants that viewed a waterpipe lounge menu in VR with health information looked at the menu for a *longer* period (mean [SD] 88.14 [18.63]) compared to participants that viewed a plain waterpipe lounge menu (mean [SD] 78.80 [20.78]).

There was an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the dwell time on the flavor area of the menu ( $p = 0.01$ ). Participants that viewed a waterpipe lounge menu in VR with health information looked at the flavor area menu for a *shorter* period (mean [SD] 21.12 [12.04]) compared to participants that viewed a plain waterpipe lounge menu (mean [SD] 28.85 [13.35]).

There was an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the dwell time on the nicotine area of the menu ( $p = 0.00$ ). Participants that viewed a waterpipe lounge menu in VR with health information looked at the nicotine area of the menu for a *longer* period (mean [SD] 19.48 [7.81]) compared to participants that viewed a plain waterpipe lounge menu (mean [SD] 6.25 [7.98]).

There was an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the dwell time on the warning message area of the menu ( $p = 0.00$ ). Participants that viewed a waterpipe lounge menu in VR with health information looked at the warning message area of the menu for a *longer* period (mean [SD] 18.09 [8.15]) compared to participants that viewed a waterpipe lounge menu (mean [SD] 3.94 [4.98]).

There was an effect of health information (warning message and nicotine content) on waterpipe lounge menus on attention as measured by the dwell time on the ingredient area of the menu ( $p = 0.048$ ). Participants that viewed a waterpipe lounge menu in VR with health information looked at the ingredient area of the menu for a *shorter* period (mean [SD] 6.47 [4.83]) compared to participants that viewed a plain waterpipe lounge menu (mean [SD] 8.49 [6.47]).

## Chapter 5: Discussion

### 5.1 Overview

Though cigarette smoking continues to decline in the U.S., young adults remain vulnerable to initiation of tobacco use through flavored products such as waterpipe. Most young adults do not perceive the health effects associated with WTS to be negative or capable of causing damage to their bodies despite the accumulating evidence that WTS presents health harms comparable to that of traditional of cigarette smoking (Cornacchione et al., 2016; Getachew et al., 2018; Rayens et al., 2017). Research also demonstrates that regardless of experience with WTS (current, former or never users), there is a low perception of addictiveness among the young adult population (Heinz et al., 2013; Mays, Arrazola, et al., 2016; Primack et al., 2008; Sharma et al., 2014; Smith-Simone et al., 2008; Ward et al., 2007). Among waterpipe users, though many are confident about their ability to quit smoking (Mays, Arrazola, et al., 2016; Smith-Simone et al., 2008; Ward et al., 2007), very few users express the intention to quit smoking (W. Maziak et al., 2005; Smith-Simone et al., 2008; Ward et al., 2007). Furthermore, while there is clear evidence of the rising prevalence of WTS among young adults and the continued misperceptions of the harmful and addictive nature of the product, the literature on development, implementation and evaluation of WTS-specific health communication strategies remain scarce.

The purpose of the research described in this dissertation was to examine the intention to quit waterpipe tobacco smoking, as well as the perceived relative harm, risk of health consequences and addiction of waterpipe tobacco smoking through a brief communication intervention. Additionally, Study 2 expanded on the results of Study 1 by allowing for examination of objective measures of individual attention to specific components of a health

communication message. The current work builds on previous WTS risk communication research on health warning messages (Islam et al., 2016; M. Jawad et al., 2013; Layoun et al., 2016; Lipkus et al., 2016; Nakkash & Khalil, 2010; Salloum, Maziak, et al., 2015) that have explored the influence of such messages on perceptions of harm, risk and addiction. Unlike some of the past studies that examined brief intervention messages, the health warning messages in this research were presented as part of a realistic, familiar setting—the hookah menu—rather than a standalone message viewed on a slide or static screen. Although there is research that has tested health warnings on waterpipe lounge menus (Salloum, Maziak, et al., 2015), Study 2 experimentally tested these concepts in a virtual reality environment. Additionally, the eye tracking metrics provided understanding of attention to the menu, and thus, a better understanding of the attention to the health information presented on the menu. Collectively, these elements positively contribute to the WTS risk communication literature and may serve as a guide for more efficacious message content and delivery for young adult waterpipe tobacco smokers.

The results of this work indicate that in different experimental conditions participants who receive general health warnings of WTS and information on the nicotine content of waterpipe tobacco increased on measures of perceived relative harm, health risk and addiction compared to those who did not receive this content on lounge menus. This is consistent with the conceptual model (based on the Message Impact Framework) used to guide this dissertation that predicted that reactions triggered by a warning message on the waterpipe lounge menus may facilitate change in WTS attitudes and beliefs, as well as intention to quit smoking waterpipe. For example, Study 1 demonstrated that those who received information on general health warnings of WTS had greater perceived harm and risk of decreased lung function from WTS.

Additionally, Study 1 showed that those that received information on nicotine content had a greater perceived risk of heart attack from WTS. Although not examined in the current analysis, it would be of interest to further explore why exposure to nicotine content versus a health warning produced an increased perception of health risk, but for different health outcomes. Contrasting Study 1, Study 2 demonstrated that the combination of a health warning message and nicotine content on waterpipe lounge menus produced a greater intention to quit smoking in addition to greater perception of decreased lung function from WTS. Study 2 participants were exposed to the menu within a VR experience and viewing the menu in this setting may have contributed to the significant findings for addiction that were not demonstrated by Study 1.

Overall, the findings are consistent with prior research showing that brief health warning messages can increase perceptions of harm and addiction, as well as intention to quit smoking (Mays, Tercyak, et al., 2016). In addition, the current studies expand this evidence by showing that the lounge menu is a viable location for delivery of health education messages. Furthermore, it demonstrates that waterpipe smokers do indeed give attention to content on the menus as noted by the greater dwell time on the overall menu with health information—specifically, waterpipe smokers demonstrated greater fixations and dwell times on health warning message and nicotine content areas than when these areas of the menu were left blank.

## **5.2 Strengths**

There are several strengths to the research described in this dissertation. First, both studies utilized a true experimental design where participants were randomly assigned to different treatment groups. Additionally, across the different treatment groups, the only manipulation (or changed variable) was the content on the waterpipe lounge menu, all other variables were kept

constant. Since randomization of participants to conditions occurs, the post-test only design was selected as a means of reducing testing threat to validity, and participants were not given a pre-test measurement. The time between the potential pre-test and the post-test measurement would have been short, raising concerns that exposure to pretest questions may impact posttest performance (testing threat). Second, the studies used valid and reliable measures from other published studies in tobacco and health communication in data collection (construct validity). This is particularly important for data harmonization, as it allows other researchers to make more equal comparisons of this data with other tobacco risk communication studies. The outcome measures included a diverse set of data forms, including subjective (behavioral measures) and objective (eye tracking) measures. This provides a unique context to interpret the results from the research. Since the development and implementation of this research, the Hookah Smoker Scale (Phan et al., 2019) was developed to identify targets for preventing and reducing use among young adults. Newly developed and validated measures of smoking patterns specific to waterpipe should be integrated into future WTS research.

Third, the study used two unique populations, an online and a laboratory sample, to explore similar outcome measures. According to (Jeong et al., 2018), the AMT convenience samples produced generalizable findings for experimental and observational tobacco control studies. Interestingly, the demographic and tobacco use variables between the samples had a high gradient of similarity with a diverse racial/ethnic makeup of young adults and comparable patterns of tobacco product use (See Table 3 and 7). They were also comparable to other young adult populations for tobacco studies (Lipkus et al., 2014, 2016, 2016; Mays, Tercyak, et al., 2016).

Lastly, Study 2 used an emerging and innovative technology as a method for study delivery

and data collection—virtual reality and eye tracking metrics. This is likely the first WTS study that has used virtual reality. The technology provides participants with a heightened sense of realism that usually is lacking in the laboratory environment, as well as an objective indicator of participants' attention (eye tracking). Within an experimental study, there is a tradeoff between the isolation of variables (internal validity) and generalizations that can be made outside of the experiment across populations, places, and time (external validity). The more control over the study variables and conditions, the less similar the experiment becomes to the real world. However, the virtual reality tool works to address this limitation of laboratory-based studies by immersing participants in a real-world environment and improving the ecological validity.

### **5.3 Limitations**

Although, the hypothesis driven, experimental design has advantages in addressing the stated research aims and establishing strong internal validity, it is not without limitations. First, the sample populations in Study 1 and Study 2 were convenience samples and may not be representative of all young adult waterpipe tobacco smokers in the United States. At the time of the study, the legal age for tobacco consumption the State of Maryland and most state and local jurisdictions in the United States was 18 years of age. A federal law was passed in December 2019 increasing the minimum age of tobacco sales to 21 years of age (Center for Tobacco Products, 2020). However, the average age in both study populations (Study 1 and Study 2) was above the age of 21 years. The new federal law will help reduce access to all tobacco products for youth and young adults; however, the effectiveness of policy changes often take time to observe at a population level, and compliance with the new law from retailers is likely to be an challenge.

There is a potential concern with self-reported data as both studies collect subjective measurements for the primary outcome variable. In an effort to reduce respondent bias, validation check questions were imbedded in both the study screener questionnaires and main study surveys to identify participants that may provide inaccurate responses. For example, participants were asked their birthdate at the beginning of the survey and age in years at the end of the survey, and their responses were reviewed for consistency. Additionally, in Study 1, the Amazon Mechanical Turk participants had complete anonymity in survey responses, and in Study 2 the VR participants were provided privacy by self-administering the survey via a computer with a privacy screen filter. These actions were meant to encourage honest responses from participants.

A third potential limitation was that the research utilized the ‘intention to quit smoking’ measure as a proxy for purchase behavior at a waterpipe lounge. Although well-established behavioral models propose that behavioral intention is a precursor of behavior (Ajzen, 1991), behavioral economics research reveals us that consumers’ self-reported purchase intentions may not perfectly predict on future purchase behavior (Morwitz, 2014). However, the proxy measure of ‘intention to quit smoking’ is still a valuable indicator for understanding the potential impact of health warnings and product labels future smoking behavior and possible purchase behavior.

Finally, the time of exposure to the menu was controlled in each study. Participants in both studies were exposed to the menus once for about two minutes and intention to quit smoking, along with other subjective measures, was assessed immediately post-exposure. A possible limitation may be delayed effects in the outcome variables as only immediate behavioral outcomes were measured. Long-term behavioral outcomes are undetermined by this research. A review of mass media interventions for prevention smoking in young people found campaigns

that last longer and use repetitive messages (more exposure) were the most successful in changing smoking attitudes, knowledge and intention to quit (Carson et al., 2017). It is likely that young adult waterpipe smokers would need multiple instances of exposures to such warning messages to elicit notable behavioral changes.

#### **5.4 Implications for Public Health Practice and Policy**

In summary, the results this research provide promising evidence that brief risk communication interventions such as health warning messages or nicotine content on waterpipe lounge menus may increase the perceived risk of health consequences of WTS in young adults waterpipe smokers, as well as the intention to quit smoking. In addition, there is evidence through the eye tracking metrics that waterpipe tobacco smokers would pay attention to such information on the menu in the lounge environment. This highlights the importance of presenting messages to users in an environment that reflects the natural behavior and practice of WTS. There are also direct implications for the tobacco regulatory efforts of FDA. As previously described, through the Center for Tobacco products FDA has the authority to regulate waterpipe tobacco, components and parts, which includes product warning labels (U.S. Department of Health and Human Services, 2016). Additionally, the agency has the responsibility of educating the public about the harms and addictiveness of tobacco products. FDA should consider informative messages that are tailored to the product in terms of the content (harms, risk and addiction), as well as the placement of warning labels.

Currently, waterpipe tobacco falls under the category of “covered tobacco products” with products such as cigars, liquid nicotine and pipe tobacco. All “covered tobacco products” are required to be labeled with the statement: WARNING: This product contains nicotine. Nicotine

is an addictive chemical. However, there is no requirement for specific nicotine content labeling. The required warning message is generic and not specific to the tobacco product, such as waterpipe. It does not describe the specific health consequences of waterpipe tobacco smoking, but only addresses nicotine as an ingredient. There are many public misperceptions about the harms of nicotine—some still believe that nicotine is a carcinogen (S. E. Johnson, 2016; O’Brien et al., 2017). As previously described, the messages on waterpipe tobacco packaging are often not encountered by the waterpipe tobacco smokers due to the mode of delivery or consumption (Mostafa & Mohammed, 2017). However, the eye tracking metrics collected in Study 2 demonstrated that waterpipe tobacco smokers gave attention to the health warning messages and nicotine content on the lounge menus, and that this time was comparable to the attention given to the flavor information (Table 9).

In addition to product specific warning messages, FDA should consider requiring waterpipe manufacturers and retailers lounges to display nicotine content, product ingredients and toxicant yields. In the case of waterpipe tobacco lounges, requirements could be fulfilled on the menus, much like the Menu Labeling Rule for restaurants (Center for Food Safety and Applied Nutrition, 2019). Under Menu Labeling Rule, consumers have access to the calorie and nutrition information of foods on an establishments’ menu. A qualitative review of waterpipe lounge menus posted to online websites showed that physical and online menus are used heavily to promote and advertise these products (Asfar et al., 2019), but lack critical health information for consumers. Asfar and colleagues examined menus for the list of tobacco flavors, statement on age restriction, prices, innovative design and special promotions. They also suggest that waterpipe lounge menus in the physical establishments, as well as online, be regulated to require age restriction, health warning messages, disclosure of actual toxicants yield, and banning of

deceptive descriptors (e.g. natural) and colorful imagery. Timely regulatory and policy actions are needed in the coming years to curb this burgeoning epidemic among young adults in the U.S. These are early and immediate steps that may protect the health and wellbeing of our communities from the burden of tobacco use. Being that the current uptake in tobacco use among young adults is largely fueled by flavored, non-cigarette products, this will be key in preventing a generation of new tobacco users that may have otherwise not been introduced to nicotine products and preventing the adverse effects of tobacco on human health.

## **5.5 Directions for Future Research**

This research may aid in the development of an evidence-base for future health communication research of non-cigarette tobacco products. First, the current studies offer potential for additional findings beyond the outlined aims through further analyses of the datasets. For example, the mechanism for increased intention to quit smoking could be explored by examining the relationship between various outcome variables, such as harm, risk or addiction. A previous study of WTS (Mays, Tercyak, et al., 2016) demonstrated a mediation relationship between health warning messages and intention to quit through the construct of perceived relative harm. It would be of value to understand how perceptions of harm, risk and addiction may potentially explain the intention to quit in the Study 2 sample population. The objective measures of attention, fixation count and dwell time were not analyzed in relationship to the subjective behavioral outcomes. Future work may also evaluate how measures of attention may explain the changes in perceived harm, risk, addiction or intention to quit smoking. Also, additional analyses could segment waterpipe smokers by frequency of use and explore how messages are interpreted or received by different types of users. The current studies used a

waterpipe dependence measure (which included frequency of use) as a covariate; however, it may be of value to singularly examine pattern of use. Similar to past research, the current studies were composed of majority of the users who were non-daily users, which is common with WTS in the U.S. young adult population (Blachman-Braun et al., 2014). Therefore, messages relating to harm or addiction may not feel as relevant to intermittent users compared with daily users. Future studies should include post-test follow-ups after the study to observe any delayed treatment effects and track possible cessation post-exposure to health information on WTS.

Finally, future studies should use the VR experience to examine the effects of different message content, framing, design, color, sizing and placement on the menu or waterpipe on smoking attitudes, knowledge and intentions to quit. Moreover, experimental studies utilizing VR interventions could be developed to allow for user initiated actions that enable physical interactions with the VR environment for more realistic sensations and measurement of additional behavioral responses. Equipment such as joysticks, hand controllers or data gloves that sense the body's movements could be incorporated into the experimental design to allow users to act out smoking a waterpipe, passing the hose of a waterpipe to a friend or making a product purchase from the lounge staff. Again, these suggested directions of future research will likely contribute to the evidence base for tobacco risk communication literature, aid in the development of future tobacco risk communication research and inform policy decisions for non-cigarette products.

## Appendix A—Lebanon Waterpipe Dependence Scale

1. Number of times you could stop waterpipe for more than 7 days?
  - a. None (3)
  - b. Once (2)
  - c. Several times (1)
  - d. It always happens (0)
2. What percentage of income would you spend for waterpipe smoking?
  - a. 1% or less of your monthly income (0)
  - b. 2%–10% of your monthly income (1)
  - c. 11%–50% of your monthly income (2)
  - d. more than 50% of your monthly income (3)
3. Number of days you could spend without waterpipe?
  - a. One day or less (3)
  - b. 2–3 days (2)
  - c. 4–7 days (1)
  - d. More than 7 days (0)
4. Number of waterpipes you usually smoke per week?
  - a. Less than 1 waterpipe/week (0)
  - b. 1–2 waterpipes/ week (1)
  - c. 3–6 waterpipes/week (2)
  - d. 7 or more waterpipes/week (3)
5. Do you smoke waterpipe to relax your nerves?
  - a. Yes, absolutely (3)
  - b. Yes, probably (2)
  - c. Yes, maybe (1)
  - d. No (0)
6. Do you smoke waterpipe to improve your morale?
  - a. Yes, absolutely (3)
  - b. Yes, probably (2)
  - c. Yes, maybe (1)
  - d. No (0)
7. Do you smoke waterpipe when you are seriously ill?
  - a. Yes, absolutely (3)
  - b. Yes, probably (2)
  - c. Yes, maybe (1)
  - d. No (0)
8. Do you smoke waterpipe alone?
  - a. Yes, always (3)
  - b. Yes, most of the times (2)
  - c. Yes, sometimes (1)
  - d. No, never (0)
9. Are you ready not to eat in exchange for a waterpipe?
  - a. Yes, absolutely (3)
  - b. Yes, probably (2)
  - c. Yes, maybe (1)
  - d. No (0)
10. Do you smoke waterpipe for pleasure?
  - a. Yes, absolutely (3)
  - b. Yes, probably (2)
  - c. Yes, maybe (1)
  - d. No (0)
11. Do you smoke waterpipe to please others?
  - a. Yes, absolutely (3)
  - b. Yes, probably (2)
  - c. Yes, maybe (1)
  - d. No (0)

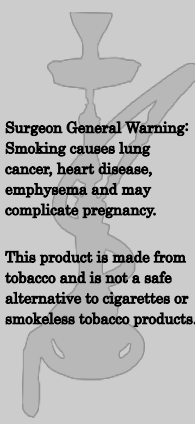
Factor 1: Physiological Dependence Questions 1-4  
Factor 2: Negative Reinforcement Questions 5-6  
Factor 3: Psychological Craving Questions 7-9  
Factor 4: Positive Reinforcement Questions 10-11  
Scoring: Sum of Each Factor

## Appendix B—Waterpipe Lounge Menus

### Group 1

**HOOKAH MENU**

Shisha Tobacco \$16  
Refill \$9

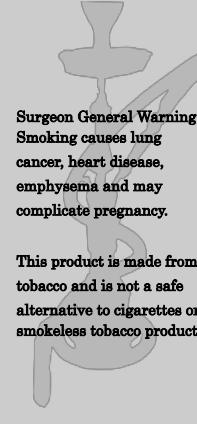
<b>Coconut</b>	0.05% nicotine 0.10% nicotine	 <p><b>Surgeon General Warning:</b> Smoking causes lung cancer, heart disease, emphysema and may complicate pregnancy.</p> <p><b>This product is made from tobacco and is not a safe alternative to cigarettes or smokeless tobacco products.</b></p>
<b>Double Apple</b>	0.05% nicotine 0.10% nicotine	
<b>Grape</b>	0.05% nicotine 0.10% nicotine	
<b>Mango</b>	0.05% nicotine 0.10% nicotine	
<b>Mint</b>	0.05% nicotine 0.10% nicotine	
<b>Orange Mint</b>	0.05% nicotine 0.10% nicotine	
<b>Strawberry</b>	0.05% nicotine 0.10% nicotine	
<b>Vanilla</b>	0.05% nicotine 0.10% nicotine	

**Product Ingredients :**  
Virginia Tobacco, Honey, Glycerin, Flavor.

### Group 2

**HOOKAH MENU**

Shisha Tobacco \$16  
Refill \$9


<b>Coconut</b>		 <p><b>Surgeon General Warning:</b> Smoking causes lung cancer, heart disease, emphysema and may complicate pregnancy.</p> <p><b>This product is made from tobacco and is not a safe alternative to cigarettes or smokeless tobacco products.</b></p>
<b>Double Apple</b>		
<b>Grape</b>		
<b>Mango</b>		
<b>Mint</b>		
<b>Orange Mint</b>		
<b>Strawberry</b>		
<b>Vanilla</b>		

**Product Ingredients :**  
Virginia Tobacco, Honey, Glycerin, Flavor.

### Group 3

**HOOKAH MENU**

Shisha Tobacco \$16  
Refill \$9


<b>Coconut</b>	0.05% nicotine 0.10% nicotine	
<b>Double Apple</b>	0.05% nicotine 0.10% nicotine	
<b>Grape</b>	0.05% nicotine 0.10% nicotine	
<b>Mango</b>	0.05% nicotine 0.10% nicotine	
<b>Mint</b>	0.05% nicotine 0.10% nicotine	
<b>Orange Mint</b>	0.05% nicotine 0.10% nicotine	
<b>Strawberry</b>	0.05% nicotine 0.10% nicotine	
<b>Vanilla</b>	0.05% nicotine 0.10% nicotine	

**Product Ingredients :**  
Virginia Tobacco, Honey, Glycerin, Flavor.

### Group 4

**HOOKAH MENU**

Shisha Tobacco \$16  
Refill \$9

<b>Coconut</b>		
<b>Double Apple</b>		
<b>Grape</b>		
<b>Mango</b>		
<b>Mint</b>		
<b>Orange Mint</b>		
<b>Strawberry</b>		
<b>Vanilla</b>		

**Product Ingredients:**  
Virginia Tobacco, Honey, Glycerin, Flavor.

## Appendix C—Institutional Review Board Approval Letter



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DATE: February 21, 2019

TO: Azieb Kidanu, MPH  
FROM: University of Maryland College Park (UMCP) IRB

PROJECT TITLE: [1192389-6] Communicating health effects of waterpipe use to young adults.  
REFERENCE #:  
SUBMISSION TYPE: Continuing Review/Progress Report

ACTION: APPROVED  
APPROVAL DATE: February 21, 2019  
EXPIRATION DATE: March 17, 2020  
REVIEW TYPE: Expedited Review

REVIEW CATEGORY: Expedited review category # 7

Thank you for your submission of Continuing Review/Progress Report materials for this project. The University of Maryland College Park (UMCP) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

Prior to submission to the IRB Office, this project received scientific review from the departmental IRB Liaison.

This submission has received Expedited Review based on the applicable federal regulations.

This project has been determined to be a MINIMAL RISK project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of March 17, 2020.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Unless a consent waiver or alteration has been approved, Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others (UPIRSOs) and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

## Appendix D

**Table 3**

***Study 1 Participant Characteristics by Experimental Condition***

	<b>Full Sample</b>	<b>Group 1 HW+NC</b>	<b>Group 2 HW</b>	<b>Group 3 NC</b>	<b>Group 4 Plain</b>
	N = 213	N = 54	N = 54	N = 53	N = 52
<b>Age (M, SD)</b>	22.48 (1.90)	22.93 (1.25)	22.17 (1.94)	22.57 (2.60)	22.27 (1.47)
<b>Gender (n,%)</b>					
Male	117 (54.9%)	33 (61.1%)	32 (59.26%)	29 (54.72%)	23 (44.23%)
Female	96 (45.07%)	21 (38.89%)	22 (40.74%)	24 (45.28%)	29 (55.77%)
<b>Race (n, %)</b>					
White	129 (60.56%)	33 (61.11%)	28 (51.85%)	31 (58.49%)	37 (71.15%)
Black	22 (10.33%)	6 (11.11%)	7 (12.96%)	6 (11.32%)	3 (5.77%)
Asian	26 (12.21%)	8 (14.81%)	6 (11.11%)	6 (11.32%)	6 (11.54%)
Latinx	17 (7.98%)	4 (7.41%)	5 (9.26%)	4 (7.55%)	4 (7.69%)
Native	1 (0.47%)	0 (0%)	1 (1.85%)	0 (0%)	0 (0%)
Multi-Racial	18 (8.45%)	3 (5.56%)	7 (12.96%)	6 (11.32%)	2 (3.84%)
<b>Education (n, %)</b>					
High School	123 (57.75%)	26 (48.15%)	35 (64.81%)	32 (60.38%)	30 (57.69%)
College	90 (42.25%)	28 (51.85%)	19 (35.19%)	21 (39.62%)	22 (42.31%)
<b>LWDS (n, %)</b>					
Heavy (more than 6 pipes per week)	5 (2.35%)	1 (1.85%)	0 (0%)	3 (5.66%)	1 (1.92%)
Moderate (3-6 pipes per week)	24 (11.27%)	5 (9.26%)	4 (7.41%)	10 (18.87%)	5 (9.61%)
Mild (less than 3 pipes per week)	184 (86.38%)	48 (88.89%)	50 (92.59%)	40 (75.47%)	46 (88.46%)
<b>Cigarette Smoker (n, %)</b>					
Current	86 (40.38%)	23 (42.59%)	21 (38.89%)	22 (41.51%)	20 (38.46%)
Ever	102 (47.89%)	25 (46.30%)	27 (50.00%)	24 (45.28%)	26 (50.00%)
Never	25 (11.74%)	6 (11.11%)	6 (11.11%)	7 (13.21%)	6 (11.54%)
<b>Tobacco Use (n, %)</b>					
Waterpipe Only	63 (29.58%)	20 (37.04%)	14 (25.93%)	11 (20.75%)	18 (34.62%)
Dual use (waterpipe and one other tobacco product)	83 (38.97%)	19 (35.19%)	23 (42.49%)	22 (41.51%)	19 (36.54%)
Poly use (waterpipe and two or more tobacco products)	67 (31.46%)	15 (27.78%)	17 (31.48%)	20 (37.74%)	15 (28.85%)

## Appendix E

**Table 4**

*Study 1 Average (SD) of Dependent Measures by Experimental Condition*

	<b>Group 1 HW+NC</b>	<b>Group 2 HW</b>	<b>Group 3 NC</b>	<b>Group 4 Plain</b>	
	<b>N = 54</b>	<b>N = 54</b>	<b>N = 53</b>	<b>N = 52</b>	<b><i>p</i></b>
<b>Intention to quit (M, SD)</b>					
I intend to reduce or stop smoking hookah in the next 3 months	2.72 (1.19)	3.07 (1.01)	2.85 (0.82)	2.73 (1.14)	0.33
<b>Perceived harm (M, SD)</b>					
Indirect relative harm	1.85 (1.59)	1.74 (1.56)	1.81 (1.32)	2.56 (1.54)	0.04*
<b>Perceived risk (M, SD)</b>					
Risk of cancer	4.37 (1.36)	4.65 (1.40)	4.53 (1.64)	4.40 (1.65)	0.78
Risk of a heart attack	4.22 (1.76)	3.76 (1.54)	4.30 (1.65)	3.23 (1.40)	0.00*
Risk of decreased lung function	5.50 (1.31)	5.43 (1.22)	5.11 (1.54)	4.58 (1.65)	0.02*
<b>Perceived Addiction (M, SD)</b>					
Indirect relative addiction	2.44 (1.91)	2.29 (1.79)	2.38 (1.61)	3.21 (1.87)	0.06

*Note.* \*  $p < 0.05$

## Appendix F

**Table 5**

*Study 1 Average(SD) of Dependent Measures by Presence/Absence of Health Warning Message*

	<b>HW + (Group 1 &amp; 2)</b>	<b>HW – (Group 3 &amp; 4)</b>	
	<b>N = 108</b>	<b>N = 105</b>	<i>p</i>
<b>Intention to Quit (M, SD)</b>			
I intend to reduce or stop smoking hookah in the next 3 months	2.90 (1.11)	2.79 (0.99)	0.45
<b>Perceived Harm (M, SD)</b>			
Indirect relative harm	1.80 (1.56)	2.18 (1.47)	0.09
<b>Perceived Risk (M, SD)</b>			
Risk of cancer	4.51 (1.38)	4.47 (1.64)	0.90
Risk of a heart attack	3.99 (1.66)	3.77 (1.61)	0.34
Risk of decreased lung function	5.50 (1.31)	5.46 (1.26)	0.01*
<b>Perceived Addiction (M, SD)</b>			
Indirect relative addiction	2.36 (1.89)	2.79 (1.79)	0.10

*Note.* \*  $p < 0.05$

## Appendix G

**Table 6**

*Study 1 Average (SD) of Dependent Measure by Presence/Absence of Nicotine Content*

	NC + (Group 1 & 3)	NC - (Group 2 & 4)	
	N = 107	N = 106	<i>p</i>
<b>Intention to Quit (M, SD)</b>			
I intend to reduce or stop smoking hookah in the next 3 months	2.79 (1.02)	2.91 (1.08)	0.43
<b>Perceived Harm (M, SD)</b>			
Indirect relative harm of hookah smoking	1.83 (1.45)	2.14 (1.59)	0.16
<b>Perceived Risk (M, SD)</b>			
Risk of cancer	4.45 (1.50)	4.53 (1.53)	0.82
Risk of a heart attack	4.26 (1.70)	3.50 (1.49)	0.00*
Risk of decreased lung function	5.31 (1.44)	5.01 (1.51)	0.13
<b>Perceived Addiction (M, SD)</b>			
Indirect relative addiction from hookah smoking	2.41 (1.76)	2.74 (1.92)	0.28

*Note.* \*  $p < 0.05$

## Appendix H

**Table 7**

***Study 2 Participant Characteristics by Experimental Condition***

	<b>Full Sample</b>	<b>Group 1 HW+NC</b>	<b>Group 2 Plain</b>
	<b>N = 96</b>	<b>N = 49</b>	<b>N = 47</b>
<b>Age (M, SD)</b>	21.11 (1.72)	21.06 (1.74)	21.17 (1.71)
<b>Gender (n, %)</b>			
Male	50 (52.08%)	24 (48.98%)	26 (55.32%)
Female	46 (47.90%)	25 (51.02%)	21 (44.68%)
<b>Race (n, %)</b>			
White	22 (22.92%)	13 (26.53%)	9 (19.15%)
Black	28 (27.08%)	16 (32.65%)	12 (25.53%)
Asian	26 (27.08%)	11 (22.45%)	15 (31.91%)
Latinx	8 (8.33%)	5 (10.20%)	3 (6.38%)
Native	0	0	0
Multi-Racial	8 (8.33%)	4 (8.16%)	4 (8.51%)
Other	4 (4.17%)	0	4 (8.51%)
<b>Age of WTS Initiation (M, SD)</b>	17.29 (2.06)	17.45 (1.84)	17.13 (2.28)
<b>LWDS (n, %)</b>			
Heavy (more than 6 pipes per week)	0	0	0
Moderate (3-6 pipes per week)	13 (13.54%)	7 (14.29%)	6 (12.77%)
Mild (less than 3 pipes per week)	83 (86.46%)	42 (85.71%)	41 (87.23%)
<b>WTS Environment (n, %)</b>			
Home	42 (43.75%)	21 (42.86%)	21 (44.68%)
Lounge	54 (56.25%)	28 (57.14%)	26 (55.32%)
<b>Cigarette Smoker (n, %)</b>			
Current	20 (20.83%)	10 (20.41%)	10 (21.28%)
Ever	43 (44.79%)	21 (42.86%)	22 (46.81%)
Never	33 (34.38%)	18 (36.73%)	15 (31.91%)
<b>Tobacco Use (n, %)</b>			
Waterpipe Only	55 (57.29%)	27 (55.10%)	28 (59.57%)
Dual use (waterpipe plus one other product)	23 (23.96%)	15 (30.61%)	8 (17.02%)
Poly use (waterpipe and two or more products)	18 (18.75%)	7 (14.29%)	11 (23.40%)

## Appendix I

**Table 8**

*Study 2 Average (SD) of Dependent Measure by Experimental Condition*

	<b>Group 1 HW + NC</b>	<b>Group 2 Plain</b>	
	<b>N = 49</b>	<b>N = 47</b>	<i>p</i>
<b>Intention to Quit (M, SD)</b>			
I intend to reduce or stop smoking hookah in the next 3 months	3.41 (0.93)	2.81 (0.99)	0.00*
<b>Perceived Harm (M, SD)</b>			
Indirect relative harm	1.80 (1.14)	2.17 (1.46)	0.16
<b>Perceived Risk (M, SD)</b>			
Risk of cancer	5.06 (1.33)	4.85 (1.52)	0.49
Risk of a heart attack	4.16 (1.43)	3.96 (1.53)	0.42
Risk of decreased lung function	5.78 (1.33)	5.13 (1.48)	0.02*
<b>Perceived Addiction (M, SD)</b>			
Indirect relative addiction	2.88 (1.64)	3.15 (1.73)	0.39

*Note.* \*  $p < 0.05$

## Appendix J

**Table 9**

*Average (SD) of Dependent Measure for Eye Tracking Metrics by Experimental Condition*

	<b>Group 1 HW + NC N = 46**</b>	<b>Group 2 Plain N = 47</b>	<i>p</i>
Menu Fixations (M, SD)	30.50 (13.56)	34.81 (13.31)	0.06
Flavor Fixations (M, SD)	31.87 (16.65)	34.77 (17.66)	0.39
Nicotine Fixations (M, SD)	33.07 (11.68)	18.81 (14.25)	0.00*
Warning Fixations (M, SD)	17.09 (7.92)	9.26 (5.26)	0.00*
Ingredient Fixations (M, SD)	10.39 (5.86)	12.98 (8.46)	0.09
Menu Dwell Time (M, SD) Seconds	88.14 (18.63)	78.80 (20.78)	0.03*
Flavor Dwell Time (M, SD) Seconds	21.12 (12.04)	28.85 (13.35)	0.01*
Nicotine Dwell Time (M, SD) Seconds	19.48 (7.81)	6.25 (7.98)	0.00*
Warning Dwell Time (M, SD) Seconds	18.09 (8.15)	3.94 (4.98)	0.00*
Ingredient Dwell Time (M, SD) Seconds	6.47 (4.83)	8.49 (5.84)	0.05*

*Note. \*  $p < 0.05$ , \*\* 3 participants removed due to invalid (impossible) values*

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