Association Between Secondhand Smoking and Cardiovascular Health Among the U.S. Adult Population Who Participated in the 2017-2018 NHANES Survey

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Abstract

The purpose of this study was to expand upon previous research by investigating the relationship between exposure to secondhand smoking and cardiovascular health in the general U.S. population across various demographic variables. Methods: Using a nationally representative sample, from the 2017-2018 NHANES survey, patterns of secondhand smoking and cardiovascular health issues were examined. This relationship was examined individually and in combination with other sociodemographic characteristics such as gender, family income/poverty, race, education level, birth country, U.S. citizenship status, and language of interview using multivariate logistic regression. Results: The data included 3882 subjects including 23.6% of participants who were exposed to secondhand smoking while 76.33% had not been exposed. Individuals who reported that they were not exposed to secondhand smoke had 32.1% lower odds (95% CI: 0.56-0.82) of having cardiovascular health issues compared to individuals who reported being exposed secondhand smoke, (95% CI: 0.56-0.82). Additionally, statistically significant associations between secondhand smoking and cardiovascular health were identified when factoring in various demographic factors such as gender, ratio of family income poverty, birth country, U.S. citizenship status, education level, and cardiovascular health issues. Conclusion: These results indicate that secondhand smoking exposure should be avoided to potentially reduce the risk of cardiovascular health issues.

Keywords: *Secondhand smoking, cardiovascular health, NHANES 2017-2018 survey*

I.   Introduction/Background

Cardiovascular disease is one of the leading causes of death worldwide and there is sufficient scientific evidence that exposure to secondhand smoke (SHS) is associated with morbidity and mortality resulting from cardiovascular disease (Peinemann et al., 2011). According to the Surgeon General Report of 2014, most individuals are exposed to secondhand smoke by smoking in their homes or in the places they work. Individuals may also be exposed to secondhand smoke in public places like bars, restaurants, and casinos, as well as in vehicles. Exposure to secondhand smoke, even for a short time, can be harmful to both children and adults. Since 1964, about 2,500,000 people who did not smoke have died from health problems caused by secondhand smoke exposure. Secondhand smoke can harm adults by causing heart disease, lung cancer and stroke. As the bodies of infants and young children are still growing, they are especially vulnerable to health risk from secondhand smoke (Tsai et al., 2018). The Germany National Health Survey 1998 estimated a prevalence of 55% for regular exposure to secondhand smoking in nonsmokers 18-79 years of age in Germany (Krebsforschugszentrum,2005).

Cardiovascular health issues are currently the leading cause of death in the United States, causing about 1 in 4 deaths (Murphy et al., 2018). Cardiovascular health issues are associated with many different factors. As the leading cause of death in United States, almost half of Americans are at risk for cardiovascular health issues including high blood pressure, high cholesterol, smoking, diabetes, obesity, poor diet, lack of physical activity and excessive alcohol consumption (CDC, 2021). Exposure to secondhand smoking can be considered as a relevant health problem. For example, cardiovascular health issues are 20 to 50% higher in subjects exposed to secondhand smoking compared to those non-exposed, causing an estimated 40,000-50,000 deaths from coronary heart disease in the United States each year (U.S. Department of Health and Human Services, 2006). A 2006 report from the US Surgeon General estimates a 25 to 30% increase in risk from coronary heart disease from SHS exposure (Moritsugu,2007). The relative risk for cardiovascular diseases in passive smokers is like that of active smokers despite almost a 100-fold lower dose of inhaled cigarette smoke (Adams et al., 2015). It has been well-documented that secondhand smoke is associated with elevated risks of coronary heart disease (Law et al., 1997; Glantz & Parmley, 1991; Wells, 1994; Steenland; 1992; Kritz & Sinzinger, 1995) and stroke (Iribarren et al.,

2004; Bonita et al., 1986; Abbott et al., 1986). Cigarette smoking as an independent modifiable risk factor for cardiovascular disease, doubles the risk of stroke. Up to 1 in 4 cardiovascular disease deaths in the United States each year are attributable to smoking (Lin et al., 2016). The Centers of Disease Prevention found that nearly half of US nonsmokers are exposed to secondhand smoke, and no risk-free level of exposure to secondhand smoke exists. Prevalence of secondhand smoking exposure is high in low- and middle-income nations, especially among women (Olasky et al., 2012).

Cardiovascular health risk indicators such as endothelial, inflammatory, and hemostatic markers all demonstrated independent associations with SHS exposure in the same direction as active smoking (Jefferis et al., 2010). For example, a study conducted on women showed that cigarette smoking also acts by potentiating other risk factors for cardiovascular disease. Cigarette smoking should be considered the most important known modifiable risk factor for coronary heart disease. Globally, it is responsible for 10% of all deaths from cardiovascular disease (Gallina et al., 2012). Secondhand smoke exposure in the very young has a detectable relationship with several markers of cardiovascular risk, long before the emergence of clinical disease (Groner et al., 2017). Groner's study was one of the first to investigate whether an association exists between five variables (e.g., last 7 day at job someone smoked indoors, at rest someone smoked indoors, in home someone smoke indoors, someone smoked in car, someone used e-cigarettes indoors) of secondhand smoking exposure and four cardiovascular issues (e.g., study participant ever had pain or discomfort in chest, get it walking uphill or in hurry, severe pain in chest for more than half hour, shortness of breath on stairs/inclines) including seven demographic factors (e.g., gender, ratio of family income to poverty, race, education level, country of birth, citizenship status) among NHANES 2017-2018 participants. Previous studies, which were focused on Japanese men population and not representative of US adult population (Abott et al., 1986), investigated the mechanistic effects (Adams et al., 2015), examined specific cardio vascular health outcome such as atrial defibrillation (Dixit et al.,2016), Pulmonary function (Eisner et al., 2007) and compared the effects of secondhand smoking with smoking (Barnoya et al., 2005).

Therefore, this study aims to determine if an association between secondhand smoking and cardiovascular health issues among the U.S. adult population who participated in 2017-2018 NHANES survey.

Although the incidence of cardiovascular health issues in women is typically lower than in men, women have a higher mortality and worse prognosis after acute cardiovascular events (DiGiosia et al., 2017). These gender differences exist in various cardiovascular health issues, including coronary heart disease, stroke, heart failure and aortic diseases (Gao et al., 2019). According to the American Heart Association (AHA) and stroke statistics published in 2016, among 5.1 million cases of heart failure, 52.9% were men and 47.1% were women. Currently, approximately three million American adult women, aged 20 and older, are develop heart failure. On average, women develop heart disease approximately ten to fifteen years later than men. Therefore, consideration of gender as a control variable is important. A previous study, conducted on household income and heart disease, showed that household income was strongly and independently associated with heart disease. Therefore, it appears that income inequality is a neglected risk factor worthy of appropriate public debate and policy intervention (Lemstra et al., 2015). An analysis of data collected by Statistics Canada from 491,083 Canadians over an 11-year period found that 2.9% of high-income Canadians had heart disease compared with 5.2% of upper middle-income residents, 8.7% of lower-middle-income residents and 9.2% of lower-income residents. Over the 11-year study period, heart disease increased by 27% and 37% in the lower-income and lower-middle-income groups, respectively, compared with 12% and 6% in the upper-middle-income and high-income groups, respectively (Lee et al., 2009).

There is substantial difference in the prevalence of cardiovascular health issues across all racial groups in U.S. In general, minorities are at higher risk of developing cardiovascular disease. Cardiovascular health issues are the leading cause of death for people of most racial and ethnic groups in the U.S. including African American, American Indian, Alaska Native, Hispanic, and White men. National Center for Health Statistics (NCHS) and National Vital Statistics System (NVSS), 11.5% of non-Hispanic white adults, 9.5% of non-Hispanic black adults, 7.4% of Hispanic adults and 6% of non-Hispanic Asians aged 18 and over had heart disease in 2017. For women, Pacific Islands and Asian American, American Indian, Alaska Native, and Hispanic women, heart disease is second only to cancer (CDC, 2021).

Socioeconomic status indicators including education, income, and occupation are associated with coronary heart disease risk factors, morbidity, and mortality. In most industrialized nations, individuals with less education, lower income, and blue-collar occupations have the highest coronary heart disease rates (Luepker et al., 1993). Several investigations have reported an association between education and risk of cardiovascular health issues. Data from three epidemiological studies in Chicago assessed whether educational level is associated with risk of death from coronary heart disease, all cardiovascular diseases, and all causes independent of the major cardiovascular health risk factors indicated inverse relationship between education and lifestyle-related risk factors at baseline and between education and long-term risk of cardiovascular health issues, coronary heart disease, and all-causes mortality (Liu et al., 1982).

The adult immigrant population has doubled from approximately 19 million in 1990 to 42 million in 2017, accounting for 17% of all US adults (Guadamuz et al., 2020). However, noncitizens, which account for half of immigrants, encounter significant barriers to healthcare access (Haq et al., 2020). For example, US non-citizens without documentation are ineligible for publicly funded health-insurance, as are many documented non-citizens as their eligibility depend on the specific visa status. Noncitizens also disproportionately face structural factors, such as poverty and residence in underserved communities, that adversely impact health and healthcare access regardless of cultural or racial/ethnic background. Therefore, their citizenship status, categorized as US born citizen and noncitizen, may contribute to disparities in cardiovascular disease, the leading cause of morbidity and mortality among immigrants (Singh et al., 2013; Fang et al., 2018). Immigrants may face barriers to healthcare or achieve control than their US counterparts (Guadamuz et al., 2020). While citizenship status may be an important contributor to these disparities, it must be controlled in the analysis. The proportion of foreign-born US adults has almost tripled since 1970. The previous study focused on cardiovascular health morbidity by birthplace among adults residing in the United States showed that comparing individual regions with those of US born adults, cardiovascular health issues were lower among foreign-born adults from Asia and Mexico, Central America, or the Caribbean. For stroke, although men from South America or Africa had the lowest prevalence, women from Europe had the lowest prevalence. Years of living in the United States was not related to risk of coronary heart disease or stroke after adjustment with demographic and health characteristics. Foreign-born adults residing in the United States had a lower prevalence of cardiovascular heart disease and stroke than US born adults. However, considerable heterogeneity of cardiovascular health issues risk was found by region of birth. Hence, birth country has been included in multivariate analysis (Fang et al., 2018).

Culture and ethnicity impact health behavior and ultimately health outcomes. More than 53 million Hispanics currently live in United States, which constitute 17% of total US population. Previous epidemiological studies, examining the incidence, mortality, and its association with cardiovascular risk factors of coronary heart disease using the information gathered by primary care practitioners on cardiovascular health of Spanish population showed that despite high prevalence of vascular risk factors, incidence proportions were lower than those reported for other countries, but similar to those reported in the few population-based studies in Spain (Marin et al., 2006). The health interviews of National Health and Nutrition Survey were conducted in respondents' homes. Many study staff are bilingual speaking English and Spanish. The study interview had two language options. The purpose of this study was to expand upon earlier research by examining the relationship of secondhand smoking to cardiovascular health issues in the general population of the U.S. participated in NHANES 2017-2018 survey.

Statement of the Problem

It has been well-established that cardiovascular disease is the leading cause of death across gender, race, and ethnicity in the United States (CDC, 2021). Despite this, the association of secondhand smoking and cardiovascular health issues remain uncertain, particularly among demographic factors. Secondhand smoking is related to many chronic diseases. The relationship; however, between secondhand smoking and cardiovascular health issues are less investigated in the U.S. Most previous studies on the association of secondhand smoking exposure and cardiovascular health issues were limited to the samples selected in specific geographic areas or specific population such as women or focusing on specific cardiovascular health conditions such as stroke or atrial fibrillation. Therefore, the generalizability of these studies is limited. Data accessing the effects of secondhand smoking on cardiovascular health issues in a general U.S. population are lacking. At present, lack of information about the reduction of secondhand smoking exposure affects the secondhand smoking awareness program from providing advice to passive smokers at high risk of cardiovascular health issues.

Aim

The aim of the study is to examine the association between secondhand smoking exposure and cardiovascular health issues variables among the U.S. adult population, who participated in the 2017-2018 NHANES datasets, using the multivariable analysis with the sociodemographic characteristics such as gender of participants, ratio of family income, poverty, race, education level, birth country, U.S. citizenship status and language of interview.

II. Methods

Study Population:

In NHANES 2017-2018, 16,211 persons were selected for NHANES from 30 different survey locations. Of those selected, 9,254 completed the interview and 8,704 were examined. Participating in NHANES was an invitation-only opportunity. The participants were selected randomly through a statistical process using U.S. census information. The selected participant represents up to 65,000 people. Age of study participants in secondhand smoking dataset is 18 years and above while age of study participants in cardiovascular health dataset

is 40 years and above. Therefore, the data analysis will be restricted to age 40 years and above because data are available on both the outcome and exposure for that age group. All observations in the database will be included, exclusive of records with missing data on key variables. The NHANES 2017-2018 was a cross-sectional study. The information on disease and risk factors was collected at the same period (Centers for Disease Control and Prevention, n.d.).

Study Instruments:

The questionnaires used in this study were selected from (1) Demographic Questionnaire, which contained gender of participants, ratio of family income poverty, race, education level, birth country, U.S. citizenship status and language of interview; (2) Secondhand smoking questionnaire, which contained last 7 day at job someone smoked indoors, at rest someone smoked indoors, in home someone smoke indoors, someone used e-cigarettes indoors; (3) cardiovascular health questionnaire, which contained ever had pain or discomfort in chest, get it walking uphill or in a hurry, severe pain in chest more than half hour, shortness of breath on stairs/inclines (Centers for Disease Control and Prevention, n.d.).

Interview Setting and Mode of Administration:

The family and sample person demographics questionnaires were administered, in the home, by trained interviewers using Computer-Assisted Personal Interview (CAPI) system. The respondent selected the language of interview (English or Spanish) or requested that an interpreter be used. Hand cards, showing response choices or information that survey participants needed to answer the questions, were used for some questions. The hand cards were printed in English, Spanish, Mandarin Chinese (both traditional and simplified), Korean, and Vietnamese. The interviewer directed the respondent to the appropriate hand card during the interview. When necessary, the interviewer further assisted the respondent by reading the response choices listed on the hand cards. Persons, 16 years, and older, and emancipated minors were interviewed directly. A proxy provided information for survey participants who were under 16 and for participants who could not answer the questions themselves (Centers for Disease Control and Prevention, n.d.).

Quality Assurance and Quality Control:

The CAPI system is programmed with built-in consistency checks to reduce data entry errors. CAPI also uses online help screens to assist interviewers in defining key terms used in the questionnaire. After collection, interview data were reviewed by the NHANES field office staff for accuracy and completeness of selected items. The interviewers were required to record interviews periodically and the recorded interviews were reviewed by NCHS staff and interviewer supervisors (Centers for Disease Control and Prevention, n.d.).

Data Processing and Editing:

Frequency counts were checked, "skip" patterns were verified, and the reasonableness of question responses was reviewed. Edits were made to variables to ensure the completeness, consistency, and analytic usefulness of the data. Edits were also made, when necessary, to address data disclosure concerns. The 2-year sample weights (WTINT2YR, WTMEC2YR) were used for all NHANES 2017-2018 analyses.

Measurement of Variables:

Sociodemographic variables selected from the demographic include individual characteristics such as gender (RIAGENDR), ratio of family income to poverty (INDFMPIR), Race/Hispanic origin w/NH Asian (RIDRETH3), Education level (DMDEDUC2), Country of birth (DMDBORN4), Citizenship status (DMDCITZN), language used during interview (SIALANG). All sociodemographic variables are considered as control and categorical variables. Gender of participants was categorized as 1=male and 2=female. Ratio of family income poverty was categorized as 1= for value less than 5 and 2=for value equal or greater than 5. Race of the study participant was categorized as 1=Black and 2=Non-Black. Education level variable was categorized as 1= less than or equal to high school graduate/GED or equivalent and 2=some college or above. Country of birth variable was categorized as 1=Born in 50 states of U.S. or Washington D.C. and 2=born in country other than U.S. Citizenship status was categorized as 1=U.S. citizen by birth or naturalization and 2= Not a U.S. citizen. Language was interview was categorized as 1=English and 2=Spanish.

Secondhand smoking exposure is a categorical variable. The variables were selected from a secondhand smoking dataset such as Last 7 day at job someone smoked indoors (SMQ858), Last 7 day at rest someone smoked indoors (SMQ862), Last 7 day someone smoked in car (SMQ872), Last 7 day in home someone smoked indoors (SMQ876), Last 7 day someone used e-cigarettes indoors (SMQ940). All smoking variables are categorical variables coded as 1=Yes and 2=No. Cardiovascular health was considered as dependent categorical variable. The variables selected from Cardiovascular health dataset such as study participant ever had pain or discomfort in chest (CDQ001), get it walking uphill or in a hurry (CDQ002), Severe pain in chest for more than half hour

(CDQ008), shortness of breath on stairs/inclines (CDQ010). All cardiovascular health variables are categorical coded as 1=Yes and 2=No.

Manipulation of variables:

NHANES 2017-2018 is based on a complex, multi-stage probability sample design. The participating sample can be extrapolated to the entire population by the sample weight variables. The sample weights incorporate the differential probabilities of selection and include adjustments for non-coverage and non-response. The sample weight is used to produce correct population estimates of prevalence and associated variances because each sample person does not have same probability of selection. Several types of sample weights are provided by the NHANES 2017-2018 to produce correct population estimates. The strata and PSU pairings from the sample design should also be taken into the account. These pairings should be used to estimate variances and test for statistical significance. Therefore, both sample weights and the complex survey design should be considered. For independent smoking variable - Last 7-day at job someone smoked indoors (SMQ858), Last 7-day at rest someone smoked indoors (SMQ862), Last 7-day someone smoked in car (SMQ872), Last 7-day in home someone smoked indoors (SMQ876), Last 7-day someone used e-cigarettes indoors (SMQ940) any one reported as 1=Yes can be considered as secondhand smoking exposure and recoded as combined new variable Secondhand smoking exposure (SMQ) value 1=Yes, and 2=No for responded as No. In any cardiovascular variable as dependent variable – Study participant ever had pain or discomfort in chest (CDQ001), study participant gets it walking uphill or in a hurry (CDQ002), severe pain in chest for more than half hour (CDQ008), shortness of breath on stairs/inclines (CDQ010) any one reported as 1=Yes can be considered as cardiovascular health issues and recoded as combined new variable cardiovascular health issues (CDQ) value 1=Yes 2=No for responded as No.

The cardiovascular health issues can be defined as if anybody ever had pain or discomfort in chest, walking uphill or in a hurry, Severe pain in chest for more than half hour or shortness of breath on stair/inclines. Secondhand smoking exposure can be defined as exposure to secondhand smoking regardless of place, situation, or type of cigarette such as indoor, at job, at rest, in car, at home or e-cigarettes. For the race variable, the plan was to investigation the association between secondhand smoking and cardiovascular health between Black and Non-black population. Therefore, all races except Blacks, can be defined as Non-Black population by combining variable codes 1,2,3,6 and 7. All demographic variables were considered as control variables. The NHANES dataset has five categories for all variables. For manipulation of variable codes, categories no, refused and don't know can be merged as no assuming the study participants doesn't have experienced the variable listed in the survey. Additionally, the secondhand smoking exposure variables suggests for secondhand smoking according to place such as car, indoor, workplace etc. For those, the variables can be merged as it eventually leads to secondhand smoking exposure as an independent variable regardless the location to create composite variable.

Treatment of Data:

The NHANES 2017-2018 dataset is based on a complex, multi-stage probability sample design. The participating sample can be extrapolated to the entire population by the sample weight variables. The sample weights incorporate the differential probabilities of selection and include adjustments for non-coverage and non-response. The sample weight is used to produce correct population estimates of prevalence and associated variances because each sample person does not have the same probability of selection. Several types of sample weights are provided by the NHANES 2017-2018 to produce correct population estimates. The strata and PSU pairings from the sample design must be considered. These pairings should be used to estimate variances and test for statistical significance.

Data Analysis:

The Statistical Package for the Social Sciences (SPSS) software used for data analysis. For univariate analysis of descriptive statistics, the distribution and n (%) can be analyzed for all variables as they are categorical. The binary logistic regression analysis was reported. Furthermore, the data analysis assumptions are random samples, independence, normality, equal variance, stability, and the measurement system is accurate and precise. Univariate analysis, such as chi-square and odds ratios first without adjustment for potential confounders, were used to examine each independent variable related to outcome variables. Chi-square analysis was used to examine statistical significance of categorical variables. The NHANES dataset has five categories for all variables was merged into two categories. Also, the dichotomous outcome can be used for 2*2 contingency tables for crosstabulation. The analysis included the cross-tabulation of relationship of secondhand smoking to confounding factors; cross-tabulation of relationship of secondhand smoking exposure to cardiovascular health; relative risk of cardiovascular health according to gender, race, income, educational level; gender and race adjusted; gender, education, ratio of family income poverty, birth country adjusted; gender, education, ratio of family income poverty, race, birth country, citizenship status, language of interviewed adjusted will be reported for weightage analysis. The duplicate values were removed. Moreover, assuming age as a control variable or confounder and

the cardiovascular health dataset is for 40 and above aged, the study participants aged 40 and above was analyzed for smoking as independent variable. As the findings of this study were dependent on the questionnaire, the assumptions can be made that the answers provided by participants are genuine, appropriate, and truthful. As there is very limited research that has been conducted on this topic, this research may provide the initiative for further studies.

III. Results

Summary of Descriptive Data

The total sample size selected from the NHANES 2017-2018 survey was 3882. Table 1 depicts variable code, variable name, variable description, variable type, and manipulation of variable code. Twenty-three percent of participants reported being exposed to secondhand smoke (Table 2). The sociodemographic distributions of selected respondents according to categories are shown in Table 2. According to Table 2, 53% of respondents were male. Socioeconomic status measured by respondent's education level and family income show a significant difference. A larger proportion of respondents (72.63%) reported a family income poverty value less than 5. For level of education, 61% of participants reported some college level and above. For race, most participants were non-black which is 88% of the total sample size. A larger proportion (81.3%) of the respondents were born within one of fifty US states or Washington D.C. Ninety-two percent of the respondents reported being US citizens by birth or naturalization and 93.8% selected English as the language of the interview. Fifty-two percent of respondents had not experienced any cardiovascular health issues.

Secondhand Smoking Exposure and Cardiovascular Health Issues

The sociodemographic distributions of selected respondents were divided into two groups based on the diagnosis are shown in Table 3. All subjects were designated as ever had cardiovascular health issues, or never had cardiovascular health issues based on self-reported history of cardiovascular variables. Among the weighted sample population, 12% had secondhand smoking exposure and experienced cardiovascular health issues while 10% didn't experience cardiovascular health issues. The proportion of females who experienced cardiovascular health issues were higher than the male participants. For gender composition, there was no difference for those who had not experienced any cardiovascular health issues. The ratio of family income/poverty did not vary between ever had cardiovascular health issues and ever not had any cardiovascular health issues. Socioeconomic status measured by respondent's educational attainment shows significant differences between who had cardiovascular health issues and who had not cardiovascular health issues. As the educational level increases, the weighted percent of cardiovascular health issues increases. A larger proportion of respondents completed some college level and above was observed in experiencing cardiovascular health issues than less than high school level and high school graduate, GED or equivalent. The proportion of African Americans having the cardiovascular health issue was lower than that in the Non-black participants. Among the black respondents the weighted percent was 5% while 43%percent among the non-black participants. However, the weighted percent was similar compared to ever had cardiovascular health issues and never had cardiovascular health issue. Forty-one percent of weighted population who had experienced cardiovascular health issues were born in the U.S. United States or Washington DC which was four times higher compared to participants born anywhere outside of the U.S. Birth country of respondents did not vary compared to ever had cardiovascular health issues and ever had not cardiovascular health issues. A similar trend was shown in the US citizenship status. Forty-five percent of US citizens by birth or naturalization reported they had cardiovascular health issues and 47% reported they had not had any cardiovascular health issues. Among the participants who were not citizen of United States, they were two times less likely to develop a cardiovascular health issues. Regarding the language of interview, 44% of participants who selected English as the language of interview had not experienced any cardiovascular health issues.

These results indicate that secondhand smoking exposure, gender, education, birth country, citizenship status is associated with cardiovascular health issues which are statistically significant (p <0.05) are shown in Table 3. According to Table 4, People who had been exposed to secondhand smoking have 32.1% lower odds of having cardiovascular health issues compared to people who were unexposed to secondhand smoking, which is statistically significant (95% CI: 0.56-0.82, P<0.0001). Females have 37.9% lower odds of cardiovascular health issues, which is statistically significant (95% CI: 1.048-1.813, P < 0.0010). In addition, respondents who have family income ratio greater than five have an 88% lower odds of cardiovascular health issues and this association is statistically significant (95% CI: 0.560-1.173, P 0.0426). High school graduates/GED or equivalent had 77% lower odds of cardiovascular health issues and it is statistically significant (95% CI: 0.700-0.863, P<0.0001). Moreover, respondents, who had been born in another country except the US, were less likely to have cardiovascular health issues which was statistically significant (95% CI: 0.364-0.62, P 0.0001). Compared to US citizens by birth or naturalization, US non-citizen had half the chance of cardiovascular health issues (95% CI: 0.339-0.694, P 0.0003).

Furthermore, after adjusting for possible confounders such as gender, race, the ratio of family income poverty, education level, birth country, US citizenship status, and language of interview, compared to people who have secondhand smoking exposure, people who did not have secondhand smoking exposure had 37.6% higher odds of having cardiovascular health issues, which is statistically significant (95% CI: 1.116-1.698, P 0.0054).

A Multivariate analysis, investigating the relationship between secondhand smoking exposure and cardiovascular health issues adjusted for control variables gender, education level, family income, poverty, citizenship status, birth country, and language, is shown in Table 4. The respondents who were not exposed to secondhand smoking had 37% higher odds of having cardiovascular health issues after adjusting for gender, education level, family income, race, citizenship status, birth country and language of interview. Females had 67.6% lower odds of cardiovascular health issues after adjusting for education level, ratio of family income poverty, race, citizenship status, birth country, language of interview variables. Among the respondents who have ratio of family income poverty value equal or greater than five had higher odds of experiencing a cardiovascular health issue after adjusting for gender, race, education level, citizenship status, birth country and language of interview. African American respondents were 19.4% more likely to experience a cardiovascular health issue after adjusting for gender, ratio of family income poverty, education level of adults, birth country, citizenship status and language of interview. Considering the education level, high school graduate or equivalent had 80% lower odds of experiencing cardiovascular health issues compared to respondents with some college or above level of educational attainment, after adjusting for other variables such as gender, ratio of family income poverty, race, birth country, citizenship status and language of interview.

The respondents who were not US citizen were 59% less likely of having any cardiovascular health issues, after adjusting for gender, ratio of family income poverty, race, educational level, birth country, citizenship status, language of interview. The respondents selecting English as a language of interview has 43% higher odds of having cardiovascular health issues, after adjusting for gender, ratio of family income poverty, race, education level of adults, birth country and US citizenship status. Additionally, after adjusting for these control variables, gender, education level, family income poverty, citizenship status, and birth country were statistically significantly associated with cardiovascular health issues.

IV. Discussion

This is the first study to examine the relationships between secondhand smoking exposure and cardiovascular health issues using a nationally-representative adult sample. The strength of this study was that the NHANES 2017-2018 data provided more detailed information about secondhand smoking exposure in a nationally representative sample. These data offered another opportunity to thoroughly examine the effects of secondhand smoking exposure in different dimensions. Furthermore, the large sample size estimated by the weighted sample, has offered greater statistical power to detect the significance of the associations of interest. The results found in nationally representative sample are more generalizable to the U.S. population than previously conducted studies in a community or subgroup of general population. The results, from this study, demonstrated that secondhand smoking is a risk factor for cardiovascular health issue. This association persisted after adjusting for other well-established risk factors for cardiovascular health issues, such as gender, ratio of family income poverty, race, education level of adults, birth country, US citizenship status and language of interview. These findings are consistent from previous studies examined association of secondhand smoking and cardiovascular health issues (Peinemann et al., 2011; Krebsforschugszentrum et al., 2005; Moritsugu et al., 2007; Adams et al., 2015; Laws et al., 1997; Glantz & Parmley et al., 1991; Wells et al., 1994; Olasky et al., 2012).

The results were not conclusive, and limitations are commonly inherent within this cross-sectional study design. The measures of secondhand smoking used in this study were based upon self-report which may be underestimated since individuals tend to underestimate the exposure of smoking. Also, since this was a cross-sectional study, the data on disease and risk factor status was collected at the same period. Therefore, the relationship between secondhand smoking exposure and risk behaviors cannot provide a time sequence. Additionally, the cross-sectional study design cannot calculate incidence.

The population selected for this study was among individuals aged 40 years and more in the U.S. While some people may have cardiovascular health issues prior to age of 40 years, they account for a very small population of the general population. Moreover, as the interviews were conducted for survey questionnaire, interviewer bias may have occurred as the interviewer may have probed more in the exposed to secondhand smoking group than the unexposed to secondhand smoking group and cardiovascular issues as outcome of interest because of the suspicion of an association between secondhand smoking exposure and cardiovascular health issues. The present study had not analyzed the other control variables such as diabetes, BMI, lack of physical activity, occupation, and health insurance status as they may associate with secondhand smoking exposure and cardiovascular health issues. The survey questionnaire consists of questions regarding ever had experience the cardiovascular health issues and never had cardiovascular health issues which may lead to information bias. There is also the possibility that the respondents were unable to recall the past exposure to secondhand smoking and

cardiovascular health issues accurately. The questionnaire includes variables for cardiovascular health issues such as study participant ever had pain or discomfort in chest (CDQ001), study participant has pain or discomfort in chest walking uphill or in a hurry (CDQ002), severe pain in chest for more than half hour (CDQ008), Shortness of breath on stairs or inclines (CDQ010) which may prone to recall bias as participants may not remember if they had experienced it rarely or earlier in the past. Also, the study variable cannot measure the severity of disease or classification of outcome.

The survey includes secondhand smoking exposure variables as last 7 days at job someone smoked indoors (SMQ858), last 7 days at rest someone smoked indoors (SMQ862), last 7 days someone smoked in car (SMQ872), last 7 days in home someone smoked indoors (SMQ876) and last 7 days someone used e-cigarettes indoors (SMQ940) include the information from the past seven days of exposure which is very short-term to analyze the development of cardiovascular issues. Also, the variables don't consist of the number of secondhand smoking exposure, how long had been exposed or the level of exposure. It cannot measure the severity or dose-response relationship between secondhand smoking exposure and cardiovascular health issues. As the cross-sectional study design only includes the data at one point of time, there is lack of follow up. Due to that, it cannot be used to analyzed behavior over a period. It does not help to determine the cause and effect. The timing of the snapshot is not guaranteed to be representative.

Several other medical conditions and lifestyle choices can also put people at a higher risk for heart disease, including diabetes, overweight and obesity, unhealthy diet, physical activity, and excessive alcohol use and health insurance coverage (CDC, 2021) should also be controlled for analysis. Cardiovascular diseases are the most prevalent cause of morbidity and mortality among patients with type 1 or type 2 diabetes. A large body of epidemiological and pathological data documents that diabetes is an independent risk factor for cardiovascular disease in both men and women (Wilson et al., 1998; Wilson, 1998; McGill et al., 1998). Cardiovascular health issues are listed as the cause of death in approximately 65% percent of diabetic patients. Diabetes acts as an independent risk factor for several forms of cardiovascular disease (National Diabetes Data Group, 1995). Moreover, secondhand smoke exposure increases the risk of developing diabetes. The greater the exposure to smoking and secondhand smoke, the greater the risk for developing diabetes (Houston et al., 2006). Obesity is associated with cardiovascular health issues. Prevalence of obesity has increased worldwide over the past few decades regardless of sex, race, and development status of the country. In the general population, obesity and especially, severe obesity (BMI $\geq$ 35 kg/m²) are consistently and strongly related with higher risk of incident cardiovascular disease and cardiovascular disease mortality (Ortega et al., 2016). In the sample population of middle-aged women, those who didn't smoke cigarettes, were not overweight, maintained healthful diet, exercised moderately to vigorously for half an hour a day, and consumed alcohol moderately had an incidence of coronary events that was more than eighty percent lower than the rest of the population. Closer adherence to a more healthful lifestyle might reduce the risk of coronary heart disease still further (Stampher et al., 2000).

Previously conducted evidence-based epidemiological study showed that physical activity is associated with reduced risk of cardiovascular health issues. Physical activity can be considered as a critical factor in both primary and secondary prevention of cardiovascular health issues. The evidence points to the benefit of continued regular moderate physical activity such as walking or gardening which are performed by larger sections of the population, confers significant benefit for cardiovascular health issues and all-cause mortality (Wannamethee & Sharper et al., 2001). Alcohol and tobacco are often used together, and alcoholism is much more common among smokers compared to non-smokers. Studies shown that cigarette smoking can increase the risk of alcohol. Since cigarette smoking includes many other chemicals, there also may contribute as an important factor on alcohol consumption (DiFranza & Guerrera, 1990).

There is proven causal relationship between higher alcohol consumption and increased risk of stroke and peripheral artery disease. Observational studies have generally shown that alcohol consumption is positively associated with cardiovascular health issues such as atrial defibrillation (Larsson & Drca, 2014) heart failure, hemorrhagic stroke (Wood et al.,2018), coronary heart disease and ischemic stroke (Larsson et al., 2016). Compared to the people with health insurance, the uninsured receive less care for cardiovascular health issues and experience higher mortality (Brooks et al., 2010).

There was no evidence suggesting that secondhand smoking leads to cardiovascular health issues. The effect of secondhand smoking on development of cardiovascular health issues may be cumulative. More research is needed to evaluate how secondhand smoking affects cardiovascular health issues. Future studies should employ longitudinal data and measure secondhand smoking in detail. It is also important for future studies to examine the interaction of secondhand smoking exposure with other risk factors related to cardiovascular health issues.

The findings from present study provide new evidence that secondhand smoking might be an independent and preventable risk factor for cardiovascular health issues. Secondhand smoking should be included in the criteria for testing cardiovascular health recommended by American Heart Association to alert individuals with high risk of cardiovascular health issues. Community screening programs should be implemented for smokers and individuals who have other risk factors for cardiovascular health.

This result has an important implication for sending a strong message of secondhand smoking cessation to significantly reduce the risk of cardiovascular health issues. Health educators could use this information to aware the people who are exposed to secondhand smoking as soon as possible, especially those individuals with other risk factors for cardiovascular health issues. This study was the first one to examine the effect of secondhand smoking exposure on cardiovascular health issues among US population participated in NHANES 2017-2018 survey. However, the results include the limitations. The control variables examined in present study such as, gender, education level, family income poverty, citizenship status, and birth country are statistically significantly associated with cardiovascular health issues. Moreover, it is unknown whether secondhand smoking exposure increases the risk of cardiovascular diseases complications and mortality of cardiovascular health issues.

V.   Conclusion

From the findings of present study, the following conclusions, which were discussed previously, are provided. Secondhand smoking should be considered an independent risk factor for cardiovascular health issues. People who exposed to secondhand smoking had a significantly higher odds of having cardiovascular health issues. Compared to people who have secondhand smoking exposure, people who do not have secondhand smoking exposure have 32.1% lower odds of having cardiovascular health issues (95% CI: 0.56-0.82) which indicates that there is statistically significant association between secondhand smoking and cardiovascular health issues risk (P value <0.0001). Gender differences existed among participants who exposed to secondhand smoking and experienced cardiovascular health issues. Males are more likely to experience cardiovascular health issues. Compared to males, females have 37.9% lower odds of cardiovascular health issues (95% CI: 1.048-1.813) which is statistically significant (P value 0.0010). Thus, the public health programs and interventions targeting individuals with high risk of cardiovascular health issues should be tailored to meet gender-specific needs. After adjusting for possible confounders such as gender, race, ratio of family income poverty, education level, birth country, US citizenship status and language of interview, Compared to people who have secondhand smoking exposure, people who do not have secondhand smoking exposure have 37.6% higher odds of having cardiovascular health issues (95% CI: 1.116-1.698) which indicates that there is statistically significant association between secondhand smoking and cardiovascular health issues (P value 0.0054). Also, the control variables such as, gender, education level, family income poverty, citizenship status and birth county are statistically significant associated with cardiovascular health issues. To prevent and delay the onset of cardiovascular health issues, the exposure of secondhand smoking exposure should be reduced.

VI.   Recommendations For Future Research

The following recommendations for further research on the association of secondhand smoking exposure and cardiovascular health issues are suggested. Other study designs need to examine the relationship between secondhand smoking exposure and cardiovascular health issues by measuring past exposure in detail since the effects of secondhand smoking on development of cardiovascular health issues might be cumulative over a long period. The true relationship may be obscured if it is only examined in secondhand smoking exposure in last seven days. Future studies that evaluate the relationships between secondhand smoking exposure and cardiovascular health issues should include diagnostic and undiagnostic cardiovascular health issues. All established risk factors associated with cardiovascular health issues should be considered to minimize the potential confounders. Since any cardiovascular health issues can be recognized as a public health issues, a simple, inexpensive, and effective predictive model for early detection and awareness of cardiovascular disease needs to be developed.

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Tables:
Table 1

Study variables

Variable code	Variable Name	Variable Description	Type	Manipulation of Variable Codes
SEQN	Respondent sequence number	This variable is sequence number of respondents.	Character	-
SMQ858	Last 7-d at job someone smoked indoors?	This variable asks that while you were/SP was working at a job or business outside of the home, did someone else smoke cigarettes or other tobacco products indoors?	Independent Categorical Numeric	1= Yes 2= No . = Missing, Refused, don't know
SMQ862	Last 7-d at rest someone smoked indoors?	This variable asks that While {you were/SP was} in a restaurant, did someone else smoke cigarettes or other tobacco products indoors?	Independent Categorical Numeric	1= Yes 2= No . = Missing, Refused, don't know

SMQ872	Last 7-d someone smoked in car?	This variable asks that While {you were/SP was} riding in a car or motor vehicle, did someone else smoke cigarettes or other tobacco products?	Independent Categorical Numeric	1= Yes 2= No . = Missing, Refused, don't know
SMQ876	Last 7-d in home someone smoked indoors?	This variable asks that While {you were/SP was} in a home other than {your/his/her} own, did someone else smoke cigarettes or other tobacco products indoors?	Independent Categorical Numeric	1= Yes 2= No . = Missing, Refused, don't know
SMQ940	Last 7-d someone used e-cigs indoors?	During the last 7 days, {were you/was SP} in an indoor place where someone was using an e cigarette, e hookah, vape pen or other similar electronic product?	Independent Categorical Numeric	1= Yes 2= No . = Missing, Refused, don't know
CDQ001	SP ever had pain or discomfort in chest	This variable asks that {Have you/Has SP} ever had any pain or discomfort in {your/her/his} chest?	Dependent Categorical Numeric	1= Yes 2= No . = Missing, Refused, don't know
CDQ002	SP get it walking uphill or in a hurry	This variable asks that {Do you/Does she/Does he} get it when {you/she/he} walk uphill or hurry?	Dependent Categorical Numeric	1= Yes 2= No . = Missing, never walk uphill or hurries, Refused, don't know
CDQ008	Severe pain in chest for more than half hour	This variable asks that Have {you/she/he} ever had a severe pain across the front of {your/her/his} chest lasting for half an hour or more?	Dependent Categorical Numeric	1= Yes 2= No . = Missing, Refused, don't know
CDQ010	Shortness of breath on stairs/inclines	This variable asks that {Have you/Has SP} had shortness of breath either when hurrying on the level or walking up a slight hill?	Dependent Categorical Numeric	1= Yes 2= No . = Missing, Refused, don't know
RIAGENDR	Gender	This variable is about Gender of the participant.	Control Categorical Numeric	1=Male 2=Female . = Missing
INDFMPIR	Ratio of family income to poverty	This variable is the ratio of family income to poverty. The Department of Health and Human Services (HHS) poverty guidelines were used as the poverty measure to calculate this ratio.	Control Categorical Numeric	1= For value less than 5 2= For value equal or greater than 5 . = Missing
RIDRETH3	Race/Hispanic origin w/NH Asian	This variable indicates the race of the study participant.	Control Categorical Numeric	1= Black 2= Non-Black . = Missing
DMDEDUC2	Education level-Adults 20+	This variable is the highest grade or level of education completed by adults 20 years and older.	Control Categorical Numeric	1= Less than or equal to High school graduate/GED or equivalent 2= Some college or above . = Missing, Refused, don't know
DMDBORN4	Country of birth	This variable indicates the country of birth of study participants.	Control Categorical Numeric	1=Born in 50 U.S. states or Washington D.C. 2=Born in country other than U.S. . = missing

DMDCITZN	Citizenship Status	This variable indicates the citizenship status of study participants.	Control Categorical Numeric	1=U.S. citizen by birth or Naturalization 2=Not a U.S. citizen . = Missing
SIALANG	Language of Interview	This variable indicates the language of interview	Control Categorical Numeric	1=English 2=Spanish . =Missing
SMQ	Secondhand Smoking Exposure	This variable is combination of all smoking variables	Independent Categorical Numeric	1=Yes 2=No . =Missing
CDQ	Cardiovascular health issues	This variable is combination of all cardiovascular health variables	Dependent Categorical Numeric	1=Yes 2=No . =Missing

Table 2

Self-reported Descriptive Characteristics for study participants (categorical variables)

Categorical Variables	Frequency	Weighted Frequency	Percent
Secondhand Smoking Exposure			
Yes			
No	823	34279277	23.66
Gender	2659	110587904	76.33
Male	1691	67552681	46.63
Female	1791	77314499	53.36
Ratio of family income poverty			
Value less than 5	2899	105230538	72.63
Value equal or greater than 5	583	39636642	27.36
Race			
Black	879	16076168	11.09
Non-black	2603	39636642	88.90
Education level of adults			
Less than High school graduate	774	17588269	12.14
High school graduate/GED or equivalent	820	38635583	26.66
Some college or above	1888	88643329	61.18
Birth Country			
Born in 50 US states or Washington, DC	2312	117777828	81.30
Others	1170	27089351	18.70
US Citizenship status			
Citizen by birth or naturalization	3053	134576958	92.89
Not a citizen of US	429	10290222	07.10
Language of interview			
English	3064	135915033	93.82
Spanish	418	8952147	06.17
Cardiovascular health issues			
Yes			
No			
	1692	68761948	47.46
	1790	76105232	52.53

Table 3

Self-reported Descriptive Characteristics for Demographics

Independent variables	Total Weighted (%)	Ever had Cardiovascular Health issues		Never had Cardiovascular Health issues		p-value*
		Weighted N	Weighted %	Weighted N	Weighted %	
Secondhand Smoking Exposure						0.0009
Yes	23.66	18799393	12.97	15479884	10.68	
No	76.33	49962555	34.48	60625348	41.84	
Gender						<.0001
Male	46.63	29186051	20.14	38366640	26.48	
Female	53.36	39575907	27.31	37738592	26.05	
Ratio of family income poverty						0.2388
Value less than 5	72.63	51454293	35.51	53776345	37.12	
Value equal or greater than 5	27.36	17307655	11.94	22328987	15.41	
Race						0.9159
Black	11.09	7598559	05.24	8477610	5.85	
Non-black	88.90	61163389	42.22	67627622	46.68	
Education level of adults						0.0015
Less than High school graduate	12.14	9918446	06.84	7669823	05.29	
High school graduate/GED or equivalent	26.66	19673256	13.58	18962327	13.08	
Some college or above	61.18	39170246	27.03	49473083	34.15	
Birth Country						<0.0001
Born in 50 US states or Washington, DC	81.30	59831056	41.30	57946773	39.99	
Others	18.69	8930892	6.16	18158459	12.53	
US Citizenship status						0.0003
Citizen by birth or naturalization	92.89	65520317	45.22	69056641	47.66	
Not a citizen of US	07.10	3241631	02.23	7048591	04.86	
Language of interview						0.0603
English	93.82	65036756	44.89	76105232	48.92	
Spanish	06.17	3725192	02.57	135915033	03.60	

Note: Significance level determined by Rao-Scott Chi-square, p<0.05

Table 4 - *Risk of Outcome (ever had cardiovascular health issues)*

Independent Variables	Crude Odds OR (95% CI)	Full Model Adjusted Odds OR (95% CI) #
Secondhand smoking exposure		
No vs Yes	P<0.0001 0.679 (0.56-0.82) **	P 0.0054 1.376(1.116-1.698) **
Gender		
Female vs Male	P 0.0010 1.379(1.048-1.813) **	P 0.0167 0.676 (0.496-0.922) **
Ratio of family income poverty		
Value equal or greater than 5 vs Value less than 5	P 0.0426 0.810 (0.560-1.173) **	P 0.4765 1.161 (0.750-1.797) **
Race		
Black vs Non-Black	P 0.9235 1.009 (0.844-1.206)	P 0.0643 1.194 (0.988-1.442)
Education level of adults		
High school graduate/GED or equivalent vs Some college or above	P<0.0001 0.777 (0.700-0.863) **	P 0. 0006 0.807 (0.618-1.054) **
Birth Country		
Born in 50 US states or Washington, DC vs others	P<0.0001 0.476 (0.364-0.623) **	P <0.0001 0.422 (0.308-0.577) **
US Citizenship status		
Not a citizen of US vs Citizen by birth or naturalization	P 0.0003 0.485(0.339-0.694) **	P 0.0232 1.594 (1.076-2.361) **
Language of interview		
English vs Spanish	P 0.0836 0.777 (0.593-1.017)	P 0.0763 1.430 (0.958-2.135)

** significant OR for 95% CI

Adjusted for all variables shown