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Differences Between Older and Younger Adults with Diagnosed Cardiovascular Disease: An Analysis of Fels Study Data

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Abstract

Background: Cardiovascular disease (CVD) is the leading cause of mortality in the United States, responsible for 33% of all deaths. Manifestations of CVD usually appear in older adults due to many factors such as sedentary lifestyle, unhealthy diet, genetic predisposition, and smoking. CVD mirrors the trends of obesity and other chronic conditions and is becoming increasingly common in younger adults. Despite this increasing prevalence, little research has focused on younger adults with CVD. Therefore, it is unknown whether younger adults with CVD share the same characteristics as older adults with the same diseases.

Methods: Data from the Fels Longitudinal Study were analyzed for 317 participants with CVD if they were at least 18 years of age. Participants were divided into two age groups: 18 to 54 were considered ‘younger’ while 55 to 90 were considered ‘older’. Descriptive analyses were performed for the data. Chi-squared tests were performed on categorical variables while independent samples t-test and Mann-Whitney U test were used on numerical data.

Results: Younger adults with CVD had a higher BMI (p = .007), higher serum triglycerides (p = .012), higher income (p = .001), lower serum HDL (p = .008), and were more likely to be a current drinker (p = .033) than older adults with CVD.

Conclusion: This study highlights the continued need for public health efforts in addressing obesity and sedentary lifestyles at a young age.

Keywords: cardiovascular disease, CVD, diabetes, public health, young adult

Differences Between Older and Younger Adults with Diagnosed Cardiovascular Disease: An analysis of Fels Study Data

Most deaths in the United States (U.S.) result from complications of chronic diseases and at the heart of the matter is America's number one killer: cardiovascular disease (CVD). CVD, which is responsible for nearly 33% of all U.S. deaths, kills more people than the combined death toll of all cancers and chronic lower respiratory disease (Benjamin et al., 2019). CVD is considered to be any of a host of conditions affecting the heart, blood vessels, or blood (Robbins & Cotran, 2015), but most cases of CVD are a result of a complex interplay between various modifiable risk factors such as genetic susceptibility, hypertension (HTN), sedentary lifestyle, and tobacco use (Tran & Zimmerman, 2015). For the sake of this paper, the types of CVD discussed will be diseases of the heart, vasculature, or blood typically due to modifiable risk factors rather than congenital or strictly genetic etiologies.

Pathogenesis

There are various pathways leading to CVD, but one of the most common means by which CVD develops is recurrent vascular injury (Robbins & Cotran, 2015). When the cells lining vasculature are repeatedly injured, such as by chronically-elevated blood pressures or chemical damage from cigarette smoke, a pro-inflammatory state is induced, stimulating coagulation and smooth muscle proliferation in the wall of the blood vessel, resulting in a thickened vascular wall with increased likelihood of clot formation (Robbins & Cotran, 2015). As time progresses, overly-thickened vascular walls are likely to attract white blood cells, thrombi, and cholesterol-laden lipoproteins, which can become embedded in the thickened vascular wall and form fatty plaques (Robbins & Cotran, 2015). Termed atherosclerosis, this process leads to thickened, hardened arteries with a narrowed central canal for blood flow with increased risk of vascular occlusion and ischemic damage to major organs such as the brain, heart, and kidneys. Atherosclerosis is the driving factor behind most other forms of CVD, including peripheral vascular disease (PAD), coronary artery disease (CAD), and cerebrovascular disease, which can result in non-traumatic amputations, myocardial infarction (MI), and stroke, respectively (Robbins & Cotran, 2015).

Statement of Purpose

This project examines the demographic and laboratory characteristics of adults 18-54 and adults 55-90 with diagnosed CVD. The purpose was to compare these characteristics between the two groups to assess whether significant differences that could potentially inform public health and clinical interventions in younger adults may exist. Because increasing age is an independent risk factor for the development of CVD (Dhingra & Vasan, 2012), I hypothesize younger adults with CVD will tend to have higher incidence of obesity and worse hyperlipidemia than older adults with CVD.

Literature Review

Epidemiology

According to the American Heart Association's (AHA) 2018 update to their Heart Disease and Stroke Statistics (Benjamin et al. 2019), 48% of adults aged 20 and older have CVD and 12.2% of adults report having a parent or sibling with angina or MI before age 50. The Centers for Disease Control and Prevention (CDC) classify hypercholesterolemia, smoking, and HTN as key risk factors for CVD, noting that 49% of adults have one or more of these three risk factors. While mortality rates for CVD have been steadily declining since 1970, CVD remains the number one killer of both male and female Americans across most racial and ethnic groups (Weir et al., 2016).

Modifiable Risk Factors

The CDC considers HTN, hypercholesterolemia, and smoking as major risk factors for the development of CVD. The AHA includes four additional modifiable factors in their list of key risk factors: diabetes mellitus (DM), poor nutrition, overweight/obesity, and sedentary lifestyle. Roughly 30-46% of adults have HTN, 50% of whom will die from ischemic heart disease if untreated (Benjamin et al., 2019; Robbins & Cotran, 2015). Between 2005 and 2015, deaths attributed to HTN increased by 37.5% (Benjamin et al., 2019). Nearly 40% of adults have high serum cholesterol, with nearly 33% having increased levels of low-density lipoprotein (LDL), the so-called 'bad' cholesterol (Benjamin et al., 2019). The prevalence of smoking in adults 35 and younger with MI was 66.7% while in adults 65 and older it is 34.6% (Huang, Li, Zhang, & Qian, 2013).

DM prevalence in adults is estimated to be 12% while nearly 40% are estimated to have pre-diabetes (Benjamin et al., 2019). Poor nutrition, sedentary lifestyle, and high body mass index (BMI) are very common in the U.S., with 98.5% of adults having a non-ideal diet, 30% of adults not engaging in leisure time physical activity, and 38% of adults being classified as obese.

Though often overlooked as a risk factor, alcohol intake also influences CVD risk. Moderate levels of alcohol intake, defined by the 2015 Dietary Guidelines for Americans (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015) as up to one drink per day for women and two drinks per day for men, may decrease risk of certain types of CVD like MI and CHF but even low levels of intake increase risk for atrial fibrillation (Whitman et al., 2017). Alcohol abuse greatly increases the risk of CHF, MI, and atrial fibrillation to a similar degree as the aforementioned risk factors and disproportionately impacts those without these more traditional risk factors (Whitman et al., 2017).

Non-modifiable or Poorly Modifiable Risk Factors

Non-modifiable and poorly modifiable risk factors include demographics such as race, ethnicity, socioeconomic status (SES), and geographic location. These risk factors highlight disparities in which populations tend to get earlier or more severe CVD.

Black Americans tend to have worse CVD than either non-Black people of color (POC) or Whites in terms of morbidity, mortality in general, and early mortality. Black Americans are 40% more likely to have HTN than White Americans, twice as likely to have DM, and have higher prevalence of PVD and obesity (Graham, 2015). Additionally, Black Americans suffer from more severe manifestations of CVD, having higher prevalence of MI and CHF, being twice as likely to have a stroke, and 30% more likely to die from heart disease (Graham, 2015). Additionally, Black Americans tend to have more severe acute CVD events like MI and stroke and at a younger age than other racial or ethnic groups (Graham, 2015).

Compared with other racial or ethnic groups in the U.S., non-White Hispanic Americans tend to have higher rates of CVD risk factors, but lower rates of coronary heart disease and CVD overall (Graham, 2015). Mexican Americans in particular had higher prevalence of dyslipidemia, metabolic syndrome, pre-HTN, HTN, and obesity than White Americans and almost twice the prevalence of DM (Graham, 2015). However, despite also having CHF prevalence greater than for Whites but less than for Blacks, Hispanic CHF patients with preserved ejection fraction had lower in-hospital mortality than White CHF patients with preserved ejection fraction (Graham, 2015).

Despite the clear racial and ethnic disparities in CVD, SES and geographic location also play major roles in determining what communities are disproportionately affected by CVD. SES has many times been linked with CVD development, and it is suggested that the effect is on par with other traditional risk factors such as HTN, smoking, hypercholesterolemia, and sedentary lifestyle (Schultz et al., 2018; Stringhini et al., 2017). Low income, one component of SES, has been linked to an increased risk of MI and sudden cardiac death even after adjusting for factors such as smoking and alcohol consumption. The effect possibly extends to neighborhood income as well, with increasing median income being associated with decreasing CVD mortality risk for the whole neighborhood (Schultz et al., 2018). However, SES alone does not fully account for a population's burden of CVD, as U.S. states with the lowest burden of CVD have residents whose wealth, educational attainment, and other measures of SES vary widely (Global Burden of Cardiovascular Diseases Collaboration, 2018).

Interventions

The AHA recommends multi-component, evidence-based interventions to target CVD. They divided the interventions into three levels of approach: individual-based interventions between healthcare providers and their patients, healthcare systems approaches which systemically influence and support healthcare providers, and population-based approaches which address factors outside the typical medical scope (Benjamin et al., 2019). Individual-based approaches recommended by the AHA focus on patient self-efficacy and accountability as well as building rapport between patient and provider. Such approaches include agreeing on specific, discrete, proximal goals for behavior change with personalized plans; encouraging self-monitoring of diet, physical activity, and other behaviors through a diary or other recording method; and regular follow-up between the patient and provider at clear intervals for feedback, goal re-assessment, and continual encouragement. These interventions have been associated with better clinical outcomes (Artinian et al., 2010; Bodenheimer, 2005). For patients in the pre-contemplative or contemplative stages of change, techniques such as motivational interviewing are recommended (Artinian et al., 2010; Benjamin et al., 2019) though there is conflicting evidence on whether the addition of motivational interviewing is effective in bringing about long-term behavioral changes which reduce CVD risk and disease burden (Hardcastle, Taylor, Bailey, Harley, & Hagger, 2013; Ismail et al., 2019; Pietrabissa, Manzoni, Rossi, & Castelnuovo, 2017).

Interventions aimed at healthcare systems target electronic health records, provider reimbursement, and provider training. The AHA recommends utilizing electronic health records to assess, track, and report on health behaviors and markers so providers can be provided feedback and guidelines regarding individual patient risk factors. More systemically, the AHA recommends incentivizing providers through reimbursements for careful monitoring of CVD risk factors and making efforts to address the modifiable behaviors and laboratory markers, which may increase provider willingness to address modifiable risk factors (Simpson & Cooper, 2009). The implementation of interventions at individual, healthcare, and systemic levels could be especially beneficial to younger adults, who typically have not yet solidified their health habits and are still able to greatly reduce their CVD risk (Gooding et al., 2017; Gupta et al., 2014; Liu et al., 2012).

Cardiovascular Disease in Young Adults

While CVD in general claims 33% of American lives, the most common cause of mortality falling under CVD would be MI, which is responsible for 25% of American deaths. The average age of first MI is 65 years for males and 72 years for females (Benjamin et al., 2019), but 10% of MIs occur in early adulthood before the age of 45 (Harvard Health Publishing, 2019; Robbins & Cotran, 2015) and the proportion of MIs occurring in young adults is increasing (Arora et al., 2019). In a study looking at young adults 35 to 54 years with acute MI, Arora et al. (2019) found that while adults in this age range comprised 27% of all MI hospital admissions between 1995 and 1999, the proportion jumped up to 32% from 2010 to 2014. CVD is mirroring the trend first noticed in type II diabetes mellitus (T2DM) and obesity: increasing prevalence in adolescents and young adults (Dodson, 2017). However, while the earlier onset of obesity and T2DM have garnered public health and research interest, relatively little attention has been paid to CVD in young adults (Tran & Zimmerman, 2015).

Part of the reason behind the paucity of relevant evidence lies in the inconsistent definition of a ‘young adult’. Some authors based their age intervals on the association of increased risk of coronary heart disease (CHD) after the age of 40 (Bucholz, Gooding, & Ferranti, 2018; Tran & Zimmerman, 2015; Tsai et al., 2018) while others chose 55 as the upper limit of what is considered ‘young adult’ (Arora et al., 2019; Barrabés et al., 2017; Gooding et al., 2017). Some authors chose a different age for males and females in line with the phenomenon of cardioprotective premenopause (Tran & Zimmerman, 2015), choosing 55 and 65 as the upper limits for males and females, respectively (Akosah, Schaper, Cogbill, & Schoenfeld, 2003; Dib, Alameddine, Geitany, & Afiouni, 2008).

The lack of research regarding young adult CVD is an oversight in the public health and clinical worlds because the beginnings of CVD start in childhood. Fatty streaks in the coronary arteries, the first grossly visible atherosclerotic plaques, begin in young childhood and increase in prevalence by 50% between ages 2 to 15 and 85% between ages 21 to 39 (Tran & Zimmerman, 2015). Additionally, some authors conclude a substantial proportion of young adults already have CVD or non-congenital cardiovascular anomalies, with some estimates exceeding 60% (Tsai et al., 2018).

There are few randomized controlled trials for CVD screening and treatment in adults 21 to 39, suggesting undertreatment in at-risk young adults (Tran & Zimmerman, 2015). In a study by Dib, Alameddine, Geitany, and Afiouni (2008) on young Lebanese adults, 80% of young adults with acute MI did not meet the Framingham risk predictor model criteria for prescription lipid-lowering therapies despite 80% of patients having obesity, 72% with significant smoking histories, and over 90% with two or more risk factors for CVD. Similarly, Akosah, Schaper, Cogbill, and Schoenfeld (2003) found that in their study population of young American adults with acute MI, only 25% of patients met criteria for lipid-lowering therapy prior to MI despite having multiple risk factors. Additionally, young adults have little awareness about their conditions if they have significant risk factors for CVD. Bucholz, Gooding, and Ferranti (2018) found that in adults under 40, 43% with hypercholesterolemia, 37% with HTN, and 30% with T2DM were aware of having those various conditions but were not being treated while 75% with borderline-high cholesterol, blood pressure, and blood glucose were unaware of their abnormal results.

The scant information on young adult CVD potentially hurts a particular subpopulation by increasing risk of disease burden and death: young, cisgender women. While 75% of all young adults with MI in Akosah et al. (2003) did not meet criteria for risk-reducing treatment before a major CVD event, the proportion of young women specifically who did not meet criteria was as high as 82%. This could potentially increase morbidity and mortality in young women with CVD, especially when considering they have poorer CVD outcomes than young, cisgender men. Young women with acute MI may have a different pathogenesis than young men, which could affect outcome measures due to underdiagnosis (Barrabés et al., 2017; D'Onofrio et al., 2015). Young women may be less likely to have traditionally recognized electrocardiogram

(ECG) changes indicative of acute MI, though they may be more likely to display ECG changes associated with less successful cardiac reperfusion, greater area of infarct, and therefore greater change of mortality (Barrabés et al., 2017). However, some authors note decreasing mortality in young women with acute MI while mortality rates for young men remain stagnant (Gupta et al., 2014). Other authors noted that while in-hospital mortality is worse for young women with MI, one-year mortality was equal between men and women (Tsai et al., 2018).

The dearth of literature addressing CVD risk factors in young adults is especially problematic given the growing population of young adults in the U.S. presenting with MI or other manifestations of CVD. This study aims to help fill that gap somewhat by comparing risk factors in young adults with diagnosed CVD to those of older adults with the same diagnoses.

Methods

Background

This study used a secondary analysis of the CVD files of the Fels Longitudinal Study dataset gathered by Wright State University Boonshoft School of Medicine and made available through Research Electronic Data Capture (REDCap). This study was exempt from Wright State University's Institutional Review Board evaluation as it did not fall under 45 CFR part 46 of the Human Subjects Regulations Decision Chart 1 (Appendix A). While the Fels dataset does provide information about living individuals, this study did not include any intervention or interaction with survey respondents and the data was de-identified prior to its retrieval from REDCap.

Having begun in 1929, the Fels Longitudinal Study is the world's longest-running study on human growth, aging, and body composition changes over the course of the lifespan of participants. The study is a multi-generational, prospective cohort study with over 1,200 participants living in primarily in the Ohio-Indiana-Kentucky Tri-State area. Participants are routinely examined every three months during the first year of life, every six months until age 18, and every two years afterward. The data collected includes demographic information, body composition, and a comprehensive medical history for participants between the years 2003 and 2017.

Inclusion Criteria

Participants were included in the study if they were at least 18 years of age and were diagnosed with one or more of the following cardiovascular conditions: angina, arteriosclerosis, congestive heart failure (CHF), myocardial infarction (MI), hypertension (HTN), cardiac ischemia, peripheral artery disease (PAD), stroke, transient ischemic attack (TIA), cardiac valvular disease, or diabetes mellitus (DM). Despite its endocrinologic etiology, DM was considered a cardiovascular disease for this study because its pathogenesis lends to most complications involving vasculature (Robbins & Cotran, 2015). Atherosclerosis has increased incidence in DM patients as well as accelerated development compared with patients without DM (Thiruvoipati, Kielhorn, & Armstrong, 2015). DM patients make up 60% of those with MI and 76% of patients with severe limb ischemia have DM (Thiruvoipati et al., 2015).

Statistical Analysis

Analysis was performed using Statistical Package for the Social Science (SPSS Version 25) and $\alpha = .05$ was the threshold of significance for all hypothesis testing. Demographics, serum laboratory values, and diagnostic characteristics of respondents were analyzed with descriptive methods. Results for each variable were split by age group: the ‘younger’ adults ages 18 to 54 and the ‘older’ adults ages 55 to 90. While there is no consensus on a definitive age range for what is considered ‘young adult’ (Tran & Zimmerman, 2015), choosing adults below 55 years of age is consistent with recent CVD studies comparing characteristics and outcomes between older and younger adults (Arora et al., 2019; Barrabes et al., 2017; Dib et al., 2008; Gooding et al., 2017).

Nominal and ordinal data such as race and drinking status were recorded as frequencies in both count and percent form. Regarding race, analysis of each racial group recorded was not possible because 311 of the 317 respondents were White. All other races were collapsed into one, POC, to allow for quantitative analysis. Means and standard deviations were reported for continuous data variables such as yearly household income and serum lipid levels. BMI was recorded as both a continuous and ordinal variable. It was recorded as a continuous variable to allow for a quick overview on body composition differences between older and younger adults. Because a mean BMI could easily be skewed by outliers, BMI was also recorded as an ordinal variable to illustrate the BMI distribution of respondents within each group. As an ordinal variable, BMI was grouped into five clinically-relevant categories: BMI less than 18.5 represents underweight respondents, 18.5 to 24.9 represents normoweight respondents, 25.0 to 29.9 represents overweight respondents, 30.0 to 39.9 represents obesity, and BMI greater than or equal to 40.0 represents morbid obesity.

Further analysis involved chi-squared tests as appropriate for categorical variables and either independent, two-sample t-test or Mann-Whitney U test as appropriate for numerical variables. For each test, the ‘younger adult’ group was compared with the ‘older adult’ group.

Results

Sample Characteristics

A total of 317 individuals were included in analysis, with 83 respondents in the ‘younger adult’ category and 234 in the ‘older adult’ category. The descriptive statistics for the sample of adults 18 and older are reported in Table 1 by age group.

Table 1

Characteristics of Respondents, by Age Group

Independent variable	**18-54 years (*N* = 83), *n*(%)**	**55-90 years (*N* = 234), *n*(%)**
Sex		
Male	49 (59.0)	112 (47.9)
Female	34 (41.0)	122 (52.1)
Race		
White	82 (98.8)	229 (97.9)
POC	1 (1.2)	5 (2.1)
Income		
Mean ± SD	91236.72 ± 56380.76	79114.78 ± 65410.07
BMI		
Mean ± SD	31.26 ± 7.35	29.26 ± 5.08
<18.5	2 (2.4)	0 (0)
18.5-24.9	14 (16.9)	44 (18.8)
25.0-29.9	17 (20.5)	97 (41.5)
30-39.9	40 (48.2)	88 (37.6)
≥40.0	10 (12.0)	5 (2.1)
Serum Lipid Levels		
LDL	109.34 ± 35.74	103.42 ± 32.07
HDL	47.20 ± 12.19	52.12 ± 12.98
Triglycerides	199.60 ± 187.34	137.09 ± 77.24
Total Cholesterol	185.36 ± 42.05	179.28 ± 39.71

Blood Pressure		
Systolic	123.83 ± 16.37	133.49 ± 19.21
Diastolic	80.53 ± 11.49	73.91 ± 10.86
Pack*years		
0	37 (44.6)	110 (47.0)
0-29.9	41 (49.4)	84 (35.9)
>30	5 (6.0)	40 (17.1)
Non-smoker	37 (44.6)	110 (47.0)
Smoker	46 (55.4)	124 (53.0)
Drinking Status		
Never Drinker	9 (10.8)	37 (15.8)
Former Drinker	7 (8.4)	43 (18.4)
Current Drinker	67 (80.7)	154 (65.8)
CVD Diagnosis		
Angina	1 (1.2)	14 (6.0)
Arteriosclerosis	1 (1.2)	26 (11.1)
CHF	3 (3.6)	9 (3.8)
Diabetes Mellitus	31 (37.3)	80 (34.2)
Hypertension	61 (73.5)	186 (79.5)
Ischemia	0 (0)	3 (1.3)
Myocardial Infarction	2 (2.4)	25 (10.7)
PAD	0 (0)	10 (4.3)
Stroke	3 (3.6)	7 (3.0)
TIA	1 (1.2)	17 (7.3)
Valvular Disease	1 (1.2)	11 (4.7)

Note: Abbreviations: POC=People of Color, SD=Standard Deviation, BMI=Body Mass Index, LDL=Low Density Lipoprotein, HDL=High Density Lipoprotein, CVD=Cardiovascular Disease, CHF=Congestive Heart Failure, PAD=Peripheral Artery Disease, TIA=Transient Ischemic Attack

Categorical Characteristics

Sex. No respondents were classified as intersex, so all respondents were classified as either male or female. Most of the younger adults with CVD were male, comprising 59.0% of respondents. This is in contrast with the older adults, where the division between the sexes is less pronounced and males comprise 47.9% of respondents. A chi-squared analysis was conducted to analyze the relationship between age and sex among those with diagnosed CVD. The relationship was not found to be significant, χ^2 (1, N = 317) = 3.06, p = .08.

Race. While the original Fels dataset included Black, Asian, Native American, Pacific Islander, Mexican American, and other races in its reporting, only six of the 317 respondents who met the inclusion criteria for this study were a race other than White, so those races were consolidated into the category POC for chi-squared analysis. The relationship between race and age was not found to be significant in this sample, χ^2 (1, N = 317) = 0.29, p = .59.

Self-reported drinking status. Drinking status was divided into three groups: current drinkers, former drinkers, and never drinkers. There was no distinction made between those engaging in moderate or excessive drinking nor was there quantification of the number of drinks a respondent had per day or per week. Current drinkers were the largest group within both age categories, with 80.7% of the younger adults and 65.8% of the older adults reporting that they currently consume alcohol. Former drinkers only made up 8.4% of younger adults while 18.4% of older adults report no longer consuming alcohol. Those who have never consumed alcohol made up 10.8% of younger adults in the study and 15.8% of older adults. Chi-squared analysis between drinking category and age was statistically significant, χ^2 (2, N = 317) = 6.836, p = .03.

BMI category. BMI was divided into five categories based on common BMI classification: 'underweight' at less than 18.5, 'normoweight' if between 18.5 and 24.9, 'overweight' if between 25.0 and 29.9, 'obese' if between 30.0 and 39.9, and 'morbidly obese' if BMI is greater than or equal to 40.0. Underweight BMIs made up 2.4% of younger adults in the study while no older adult fell into this category. Normoweight individuals made up 16.9% of younger adults and 18.8% of older adults. 20.5% of younger adults were overweight compared with 41.5% of older adults. Nearly half of young adults had a BMI between 30.0 and 39.9 with a 48.2% while 37.6% of older adults had a BMI in this range. The prevalence of morbid obesity was 12.0% in younger adults and 2.1% in older adults. The prevalence of overall obesity can be calculated by adding the percentages within the 30.0-39.9 and ≥40.0 ranges, putting obesity prevalence at 60.2% among younger adults in this study compared with 39.7% among the older adults. Chi-squared analysis for the five BMI groups was significant, χ^2 (4, N = 317) = 27.68, $p <$ .001.

Smoking Level. The metric used to assess smoking level in the Fels study was pack-years, which is the number of packs of cigarettes an individual smokes per day multiplied by the number of years they have been smoking. A 'heavy smoker' is classified as an individual who has at least a 30 pack-year history. The designation of heavy smoker is relevant in clinical and public health discourse because people with a 30 pack-year history are considered high-risk for developing lung cancer (U.S. Preventative Services Task Force, 2016). Because of this relevance, Table 1 shows the respondents divided into three groups based on pack-year history. However, because older smokers have the potential to have smoked for more years and could thus bias results, analysis only considered two groups: smokers and non-smokers. Non-smokers were those who had 0.00 pack-year histories while smokers were considered anyone with greater than 0.00 pack-years. Chi-square analysis was used to investigate the relationship, which was not found to be significant, χ^2 (1, N = 317) = 0.15, p = .70.

Numerical Characteristics

All data for numerical variables were first plotted in histograms to assess for whether they were normally distributed. Normally distributed variables were analyzed with independent, two-sample t-tests while variables with skewed data were analyzed with Mann-Whitney U tests.

Normally-distributed data. The variables with normal distributions included BMI, serum LDL, serum HDL, total serum cholesterol, systolic BP, and diastolic BP, and therefore the mean values between the younger and older adults were compared with independent, two-sample t-tests. The relationship between age group and serum LDL was not found to be significant with $t(315) = 1.40$, $p = .162$. The relationship between age group and total serum cholesterol was also not found to be significant with $t(315) = 1.18$, $p = .239$. BMI was significantly higher in younger adults while HDL was higher in older adults with $t(315) = 2.72$, $p = .007$ and $t(315) = -3.01$, $p = .008$, respectively. Systolic BP was higher and diastolic BP was lower in older adults than in younger adults with $t(315)= -4.08$, $p < .001$ and $t(315)= 4.70$, $p < .001$, respectively. This is consistent with expected pulse pressure changes with aging (Swaminathan & Alexander, 2006).

Skewed data. Income and serum TG were both positively skewed when plotted in histograms, so their mean values were compared using the Mann-Whitney U test. Income was found to be significantly higher in the younger age group (Median = 72000) than in the older age group (Median = 72000) with $U = 7425$, $p = .001$. Serum TG was also significantly higher in younger adults (Median = 134) than in older adults (Median = 120) with $U = 7916$, $p = .012$.

Discussion

According to the results of this study, there were no statistically significant differences between adults 18 to 54 and 55 to 90 with CVD in terms of sex, race, total cholesterol, serum LDL, or smoking status. Younger adults with CVD were statistically more likely to be obese or morbidly obese, to have higher serum TG, lower HDL, and higher income. Younger adults were also more likely to have lower systolic BP and higher diastolic BP, which is consistent with typical age differences (Swaminathan & Alexander, 2006). However, due to the limitations of this study, caution is advised when interpreting the results. Of note, relatively little research has been done on younger adults regarding CVD and there is no consensus on what is considered a 'young' adult (Tran & Zimmerman, 2015), so more research is needed in these areas.

Limitations

This study had several limitations impacting the analysis and therefore one must be cautious when interpreting the test results.

Dataset. Some of the limitations come from the Fels cardiovascular dataset used in this study. The sample respondents were predominantly White, making it difficult to compare results based on race and thus limiting the generalizability of any analysis using the dataset. The information gathered from the dataset was also very limited regarding substance use or abuse. While the number of pack-years were reported for each respondent, there was no indication of how many years each smoker had been smoking nor was there any indication of whether someone was a current smoker or a former smoker. The inverse is true regarding alcohol use where the respondents were recorded as never, former, or current drinkers, but no indication of how many drinks a person has in a typical week or whether the respondent engages in high-risk or moderate drinking. Information regarding any other drug use was absent from the dataset. Additionally, there was no indication whether participants with DM had T2DM or type I DM. Finally, while participants were identified as male and female, there was no indication whether participants were intersex or whether they were cisgender or transgender, which could potentially bias results.

Assumptions. Some limitations come from assumptions made about the data prior to analysis. For each blood pressure and laboratory measure, the assumption was that these measurements were representative of normal values for each participant. Only one value was recorded per participant per variable, but there was no indication of when each value was recorded, whether the participant was on medication, or, if medicated, whether the value was recorded before or after a treatment regimen was begun. Because there was only one of each value recorded per participant, there was no way of knowing how close to a baseline the values were.

Additionally, assumptions were made for BMI that every person in the overweight, obese, and morbidly obese categories were truly above a healthy weight for their height. Measures such as BMI do not take into consideration body composition, so anything resulting in increased body mass, such as body building or pregnancy, would be classified as 'overweight' or 'obese'. No body composition information was recorded in this data file, so it was impossible to know how many of the respondents might have had other explanations for increased body mass.

Assumptions were also made regarding the nature of the type of CVD each participant had. While the study documented 11 manifestations of CVD, it is far from all-inclusive. For instance, while angina and myocardial infarction were recorded diagnoses, CAD was not, which is relevant because while nearly everyone with a history of angina or MI have CAD, not everyone with CAD experiences angina or MI. Another important diagnosis not listed in the dataset is atrial fibrillation, which is the most common cardiac arrhythmia and a major risk factor for stroke and other embolic events (Whitman et al., 2017). It is possible that many of the participants excluded from this study have diagnosed CVD, but their specific diagnosis was not listed and thus their characteristics would not have been analyzed. Finally, it was assumed that each person with CVD developed it due to sedentary lifestyle factors and genetic predisposition rather than due to a congenital defect.

Public Health Implications

This study highlights the importance of continued public health efforts in addressing CVD risk factors at the young adult stage, an interventional 'sweet spot' because most young adults do not rely on their parents for health habits but have yet to cement their own habits (Gooding et al., 2017). Interventions advocating for delayed gratification, such as initiating and maintaining an active lifestyle to protect oneself from CVD decades later, are often difficult messages for young adults to accept (Hoek, Hoek-Sims, & Gendall, 2013), and short-term or single-component interventions for these issues are not likely to be successful (Institute of Medicine and National Research Council, 2015). However, approaches utilizing a more ecological approach show promising efficacy.

Multifaceted interventions acting at interpersonal, organizational, and policy levels, such as those used to discourage tobacco usage and encourage tobacco cessation, tend to have more robust effects which are more likely to be sustained long-term (Institute of Medicine and National Research Council, 2015). If these multifaceted approaches encourage healthy lifestyle changes in adults at a young age, their risk for CVD is much decreased by middle age (Gupta et al., 2014; Liu et al., 2012). CVD is currently costing the U.S. $329.7 billion per year in direct medical costs and indirect loss of productivity costs, which is expected to reach $749 billion by 2035 (Benjamin et al., 2019), so early intervention in young adults could improve quality of life while also saving billions in healthcare-associated costs.

Conclusion

In summary, younger adults with CVD are more likely to be obese or morbidly obese with higher TGs and lower SBP than older adults. This suggests that much of the risk for developing premature CVD lies in tangible, modifiable risk factors which can be targeted at the provider, healthcare system, and systemic levels. More research is needed regarding CVD in adults younger than 55 to increase the chance of identifying those with CVD and targeting them for intervention to curb the increasing disease burden and mortality of CVD in this age group.

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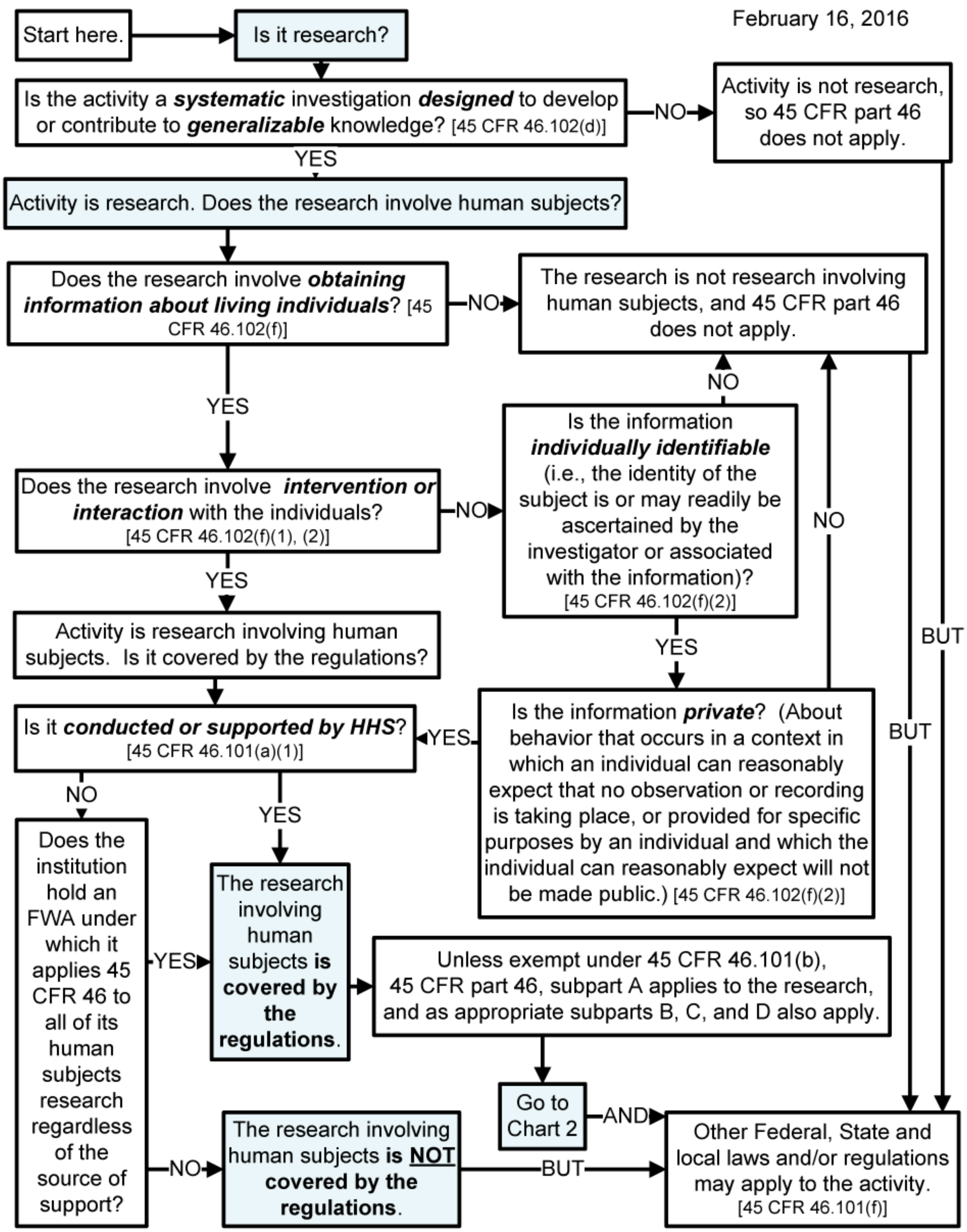
Appendix A - Human Subject Regulations Decision Chart



Appendix B: List of Competencies Met in Integrative Learning Experience

Evidence-based Approaches to Public Health	
	1. Apply epidemiological methods to the breadth of settings and situations in public health practice
	2. Select quantitative and qualitative data collection methods appropriate for a given public health context
X	3. Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate
X	4. Interpret results of data analysis for public health research, policy or practice
Public Health & Health Care Systems	
	5. Compare the organization, structure and function of health care, public health and regulatory systems across national and international settings
X	6. Discuss the means by which structural bias, social inequities and racism undermine health and create challenges to achieving health equity at organizational, community and societal levels
Planning & Management to Promote Health	
	7. Assess population needs, assets and capacities that affect communities' health
	8. Apply awareness of cultural values and practices to the design or implementation of public health policies or programs
	9. Design a population-based policy, program, project or intervention
	10. Explain basic principles and tools of budget and resource management
	11. Select methods to evaluate public health programs
Policy in Public Health	
	12. Discuss multiple dimensions of the policy-making process, including the roles of ethics and evidence
	13. Propose strategies to identify stakeholders and build coalitions and partnerships for influencing public health outcomes
X	14. Advocate for political, social or economic policies and programs that will improve health in diverse populations
	15. Evaluate policies for their impact on public health and health equity
Leadership	
	16. Apply principles of leadership, governance and management, which include creating a vision, empowering others, fostering collaboration and guiding decision making
	17. Apply negotiation and mediation skills to address organizational or community challenges
Communication	
	18. Select communication strategies for different audiences and sectors
	19. Communicate audience-appropriate public health content, both in writing and through oral presentation
X	20. Describe the importance of cultural competence in communicating public health content
Interprofessional Practice	
	21. Perform effectively on interprofessional teams
Systems Thinking	
	22. Apply systems thinking tools to a public health issue

Health Promotion and Education	
	1. Demonstrate program implementation skills.
	2. Create a health communications campaign.
	3. Monitor the implementation of health promotion programs and policies.
	4. Conduct process, impact, and outcome evaluations of health promotion programs and policies.
	5. Identify and manage resources to lead a health promotion project.
Population Health	
	1. Analyze quantitative data using multivariable adjusted regression analysis.
X	2. Apply quantitative research methodology to research a current health issue.
	3. Organize and deliver an effective presentation on a population health issue using an emerging and advanced communication strategy.
X	4. Illustrate an unmet need of population health through the synthesis of data, literature, and knowledge of policies and systems.
	5. Constructively address disagreements about values, roles, goals, or actions that arise among public health issues.