DISPARITIES IN BODY MASS INDEX OF WOMEN BY SEXUAL ORIENTATION

by

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ABSTRACT

Background: Obesity is a leading health indicator with larger body size associated with increased all-cause mortality. Sexual minority women (SMW) are reported to have higher body mass index (BMI) than heterosexual women.

Aims: The three aims of our research were to: 1) identify if, and what, differences exist in dietary intake of women by sexual orientation (SO); 2) investigate dietary consumption as a potential mediator between SO and BMI; and 3) explore current depression as a mediator with the sample stratified by lifetime history of depression.

Methods: This secondary analysis utilized **E**pidemiologic **ST**udy of **HE**alth **R**isk in Women (ESTHER) Project data. Group comparisons were made between the SO groups for dietary intake from three-day food diary data. With SO as the predictor and BMI as the outcome, three models were tested: 1) total caloric intake as a mediator; 2) macronutrients (mean daily grams of: fat, carbohydrates, protein, and alcohol) as parallel mediators; and 3) current depression as a mediator with the ESTHER sample stratified by lifetime history of depression.

Results: SMW had significantly higher BMI than heterosexual women. Even after adjusting for education level and parity, SMW had higher daily consumption than heterosexual women of: caloric intake; total fat; total monounsaturated fatty acid; and total polyunsaturated fatty acid. Alcohol intake was significantly higher for SMW than heterosexual women but not after

adjusting for education and parity. Total caloric intake and fat intake partially mediate the association between SO and BMI even when covariates are held constant (age, education, smoking status, physical activity). SMW had significantly higher rates of lifetime history of depression than heterosexual women. We did not find evidence that current depression mediates the relationship between the SO of women and BMI. We found that women with no lifetime history of depression did not have a significant association between the sexual orientation of women and BMI.

Conclusion: Our findings are of public health significance to this minority population. Research has traditionally concluded that SMW are disproportionately more overweight and obese than heterosexual women. We explored the influence of dietary intake and depression to help explain BMI differences.

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PREFACE

As written in a letter Thomas Jefferson wrote to Samuel Kercheval in 1816:

> I am not an advocate for frequent changes in laws and constitutions, but laws and institutions must go hand in hand with the progress of the human mind. As that becomes more developed, more enlightened, as new discoveries are made, new truths discovered and manners and opinions change, with the change of circumstances, institutions must advance also to keep pace with the times.

I would like to commend Deborah Aaron, PhD, now deceased, for her work to advance the research for sexual minority women and leaving a legacy to enlighten us all.

Thank you to my committee members for your support and scientific insight. I am grateful for the time you have gifted me and your dedication to education. A very special thank you to my coursework advisor, Dr. Bromberger and to my dissertation advisor, Dr. Markovic.

Earning this degree, while growing our family and working, was immensely difficult. I am so thankful for the encouragement and support from my husband, Keith, and my family. Thank you for believing this accomplishment was possible.

1.0 DISSERTATION OVERVIEW AND OBJECTIVES

Obesity is a leading health indicator with higher body size associated with increases in all-cause mortality. Sexual minority women (SMW) are reported to have higher body mass index (BMI) than heterosexual women. Sexual minorities are also reported to have higher risk of anxiety and depression compared with heterosexuals. The minority stress theory model hypothesizes that mental health disparities between sexual minorities and heterosexuals are from a stressful environment created by stigma, prejudice, and discrimination. The Institute of Medicine's first report on the health of lesbian, gay, bisexual, and transgender people reported theories on why SMW may be more obese or overweight than heterosexual women. The theories include that obesity is associated with minority stress exposure; SMW do not adhere to culturally popular ideas of body type and instead focus on body fitness; differences in exercise patterns exist between SMW and heterosexual women; and childhood sexual abuse (CSA), a risk factor for multiple deleterious health outcomes, is more prevalent among SMW.

The objective of this research was to investigate dietary intake differences between SMW and heterosexual women, test dietary consumption as a potential mediator between the sexual orientation of women and BMI; and to explore current depression as a mediator with the sample stratified by lifetime history of depression. The specific aims were to utilize the ESTHER data to:

- Compare the macronutrient intakes of SMW and heterosexual women using three-day food diary data for the unadjusted sample and after adjusting for education level and parity.
- Test mean three-day food diary total caloric intake as a mediator between the sexual orientation of women and BMI.
- Test macronutrients (mean grams of: fats, carbohydrates, protein, and alcohol) as parallel multiple mediators between the sexual orientation of women and BMI.
- Test current depression as a mediator with the ESTHER sample stratified by lifetime history of depression.

2.0 BACKGROUND

2.1 SEXUAL MINORITY RESEARCH

2.1.1 Overview of Sexual Minority Research History

A minority group in the United States has sustained, and continues to endure, immense discrimination. The discrimination comes from legislative restrictions, social stigma, and from the scientific community. Prior to 1973, when homosexuality was removed from the Diagnostic and Statistical Manual of Mental Disorders, the American Psychiatric Association (APA) viewed this minority group as ill. Research about the LGBT population focused on etiology until the psychiatric classification was removed. Beginning in the 1980's the health research for this population turned to human immunodeficiency virus research. In the 1990's, in response to the LGBT community's publicized plea, research focused on breast cancer among lesbians [1]. The lack of population-based data and representation of the LGBT population was specifically noted in Healthy People 2010 and the 1999 Institute of Medicine report on lesbian health [2]. In March of 2011 the Institute of Medicine published its first report on LGBT health [3]. Boehmer [1] conducted a review of the public health research over a twenty year span. The search of all articles in the National Library of Medicine involving humans, published in English, from 1980 to 1999 found 3,822,822 articles. Of those, only 0.1% of the articles addressed the LGBT population (3,777 of 3,822,822). The articles specifically addressing lesbian health represented

27.6% of the LGBT articles identified. The Medical Subject Headings (MeSH) that the National Library of Medicine uses to index articles had simply been "Homosexuality" between 1966 and 1994 for lesbians and in 1995 the MeSH term was changed to, "Homosexuality, Female" to represent: Female Homosexuality, Lesbianism, Lesbians, and Lesbian. Given the history of research that involves the LGBT minority group, it is easy to see the room for growth.

2.1.2 National Recommendations for LGBT Research

The Institute of Medicine's 2011 publication about the first report on LGBT health [3] had specific recommendations that I would like to note here as they represent some very basic steps in studying a minority population. The recommendations were:

1. The National Institute of Health (NIH) should implement a research agenda designed to advance knowledge and understanding of LGBT health.
2. Data on sexual orientation and gender identity should be collected in federally funded surveys administered by Health and Human Services (HHS) and in other relevant federally funded surveys.
3. Data on sexual orientation and gender identity should be collected in electronic health records.
4. NIH should support the development and standardization of sexual orientation and gender identity measures.
5. NIH should support methodological research that relates to LGBT health.

6. A comprehensive research training approach should be created to strengthen LGBT health research at NIH.

7. NIH should encourage grant applicants to address explicitly the inclusion or exclusion of sexual and gender minorities in their samples.

2.1.3 Challenges in Sexual Minority Research

There are some very specific challenges when researching the LGBT population. Simply defining the group which you are studying is difficult. Sexual orientation is defined by the APA as the sex of those to whom one is sexually and romantically attracted [4]. Further, the APA guidelines define attraction to one's own sex as gay/lesbian, attraction to the other sex as heterosexual, and attraction to both sexes as bisexual. The APA cites research documenting the continuum and fluidity of sexual orientation [4]. The Institute of Medicine highlights that defining "lesbian" is one of the first challenges in studying the minority population [3]. Some research uses same-sex partners at some point since puberty, currently only having sex with same-sex partners, sexual partner preference, and primary sexual desire/relationships in the past 5 years are some examples of how the population is defined.

The LGBT population is very diverse which can pose a generalizability challenge. Even within one facet of the community, lesbians for example, there are sociodemographic characteristic differences, economic differences, and even differences in identities and traditional gender roles (e.g. 'butch', 'femme') [5,6].

2.1.4 Sexual Minority Women Population

A specific group of the LGBT population, lesbians or Sexual Minority Women (SMW) are the focus of this dissertation. As noted above identifying this population is difficult. Nationally how many women in the United States (US) identify as a sexual minority woman? The data are inconsistent but estimates range from 0.5% to 4% of the US population. The Census in 2000 used same-sex partner households to generate an estimate of 0.54% of US adult women are SMW. Gates (2011) reviewed five US national surveys and surveys from Canada, the United Kingdom, Australia, and Norway to estimate the number of SMW. In the US it was estimated that 3.4% (made up of 1.1% lesbian; 2.2% bisexual) of the women were SMW [7]. Using 1990 census data, Aaron (2003) estimated the adult lesbian population to be 1.87% in Allegheny County, PA [8]. The Institute of Medicine's 2011 publication [3] estimates 4% of the adult US population is a SMW.

2.1.5 Sexual Minority Women and Body Mass Index

The existing literature reports that SMW have a higher body mass index (BMI), than heterosexual women [9-17]. The Institute of Medicine's first report on the health of lesbian, gay, bisexual, and transgender people specifically highlighted the issue of increased obesity among SMW [3].

2.1.6 Minority Stress

The minority stress theory model is widely accepted and proposes to explain the disparities in mental health between sexual minorities and heterosexuals. The minority stress theory model hypothesizes that the stressful environment created by stigma, prejudice, and discrimination against SMW, elicits mental health issues that may, explain the greater prevalence of mental health disorders among sexual orientation minorities [18,19]. There is a higher prevalence of anxiety and depression among sexual minorities compared with heterosexuals [19-23].

2.2 LIMITATIONS IN EXISTING EPIDEMIOLOGIC LITERATURE

The existing literature reports SMW have higher BMI than heterosexual women [9-17], that sexual minorities endure a lifetime of psychological distress [18,19] and have higher rates of anxiety and depression [19-23]. The current body of literature for SMW concludes that SMW have a higher BMI than heterosexual women but have limited explanations as to the cause. To our knowledge there are no published studies that compare specific dietary intake components by sexual orientation in women. Understanding dietary intake can inform BMI disparities between SMW and heterosexual women. Investigating potential mediators of the relationship between the sexual orientation of women and BMI would also fill a gap in the existing literature. Dietary and psychological considerations may play a role in the relationship between the sexual orientation of women and BMI.

2.3 SPECIFIC AIMS

This dissertation follows the three manuscript approach and all three are secondary data analyses uses data collected in Pittsburgh, PA from the **E**pidemiologic **ST**udy of **HE**alth **R**isk in Women (ESTHER) Project.

The aim of Research Article 1 (Section 3.0) was to utilize the ESTHER three-day food diary data to compare macronutrient intake between SMW and heterosexual women. Then to adjust for education levels and parity and compare macronutrient intake between SMW and heterosexual women.

The aim of Research Article 2 (Section 4.0) was to test mean three-day food diary total caloric intake as a mediator between the sexual orientation of women and BMI and to test mean grams per day from fats, carbohydrates, protein, and alcohol as parallel multiple mediators between the sexual orientation of women and BMI.

The aim of Research Article 3 (Section 5.0) was to stratify the ESTHER sample by self-reported lifetime history of depression and test current depression as a mediator between the sexual orientation of women and BMI.

3.0 DIETARY COMPARISON BETWEEN SEXUAL MINORITY WOMEN AND HETEROSEXUAL WOMEN

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Keywords: sexual minority women, lesbian, food diary, body mass index, dietary intake

This article will be submitted for publication.

3.1 ABSTRACT

Background and Objective: Obesity is a leading health indicator with greater body size associated with increases in all-cause mortality. Sexual minority women (SMW) are reported to have higher body mass index (BMI) than heterosexual women but little has been reported concerning dietary intake differences. Our goal is to investigate variances in dietary intake by sexual orientation in women. We hypothesize that there are differences in macronutrient intake between SMW and heterosexual women.

Methods: Dietary intake data collected via a three-day food diary as part of the **E**pidemiologic **ST**udy of **HE**alth **R**isk in Women (ESTHER) Project (Pittsburgh, PA) was used for this secondary data analysis. The sample included 431 SMW and 368 heterosexual women age 35–64. Dietary analysis was performed with the Nutrition Data System for Research (NDSR) software version 2007. Unadjusted descriptive statistics and comparisons of between-group means were evaluated then adjusted for education level and parity.

Results: BMI was statistically higher among SMW than heterosexual women. No differences in physical activity were identified between SMW and heterosexual women. Macronutrient differences between sexual orientation groups were identified. SMW had statistically significant higher daily intake of total calories, total fat, total monounsaturated fatty acid, total polyunsaturated fatty acid, than heterosexual women even after adjusting for differences in education and parity. Alcohol intake, and percent of calories from alcohol per day, were

significantly higher among SMW than heterosexual women but the statistically significant group differences ceased when adjusting for education and parity.

Conclusion: This is the first study to use three-day food diary data to explore differences in macronutrient intake between SMW and heterosexual women. Total caloric intake and intake of fat was significantly higher among SMW than heterosexual women which could explain disparities in BMI of women by sexual orientation. Intake of alcohol was higher among SMW than heterosexual women but not after adjusting for education and parity.

3.2 INTRODUCTION

The obesity epidemic in the United States is continuing to rise despite published national goals. The Healthy People goal for 2010 was an obesity (body mass index [BMI] $\geq$30 kg/m^2) prevalence of $\leq$15% but no state met that goal [1]. The Healthy People goal for 2020 is to have an obesity rate of $\leq$30.5% [2]. Among United States (US) adult women age 20 and older, 36.1% were obese in 2011–2012 [3].

Obesity is seen as a leading health indicator, with greater body size associated with increases in all-cause mortality. Obesity is associated with increased risk of hypertension, dyslipidemia, type 2 diabetes, coronary heart disease, stroke, gallbladder disease, osteoarthritis, respiratory problems, and certain cancers (including breast, endometrial, colon) [4]. Obesity is a preventable risk factor associated with the leading cause of death among women—cardiovascular disease (CVD). About a quarter of US adult women die from CVD [5]. There has been a national call

for action to lower obesity rates through avenues such as Healthy People and The Women's Heart Health Initiative [6,7].

A group of women who may be at a particularly high risk of CVD are sexual minority women (SMW). SMW have a greater number of risk factors for CVD, including higher BMI, than heterosexual women [8-15]. The Institute of Medicine's first report on the health of lesbian, gay, bisexual, and transgender people (which was published in March 2011) specifically highlighted the issue of increased obesity among SMW [16]. Risk for obesity can be better understood if more is known about SMW's food consumption.

Only three studies have evaluated differences in food intake between SMW and heterosexual women, and all utilized limited variables for food intake [10,15,17]. Valanis and colleagues (2000) evaluated data from the Women's Health Initiative (n=93,311; n=573 "lifetime lesbian" or "adult lesbian"), which used the Food Frequency Questionnaire. The Food Frequency Questionnaire is a self-report of usual frequency of consumption and portion sizes from a list of foods. Daily value of fruit and vegetable servings were categorized into: <2 servings; 2–3 servings; 4–5 servings; and ≥6 servings. Using multivariate logistic regression analyses, the study showed SMW had lower intake of fruits and vegetables than heterosexual women [15]. Roberts and colleagues (2003) conducted a smaller study that used convenience snowball recruitment of 324 SMW and a heterosexual sister. The nutritional variables included the past year's consumption of red meat, caloric intake of more than 30% from fat, a low-fat diet, and a vegetarian diet in the past year. Using paired data, the only difference between the sisters was that the SMW were less likely to have eaten red meat in the past year [17]. Finally, Boehmer and Browen (2009) used data from the California Women's Health Study (2001–2005) which assessed energy intake based on average daily servings of fruits/vegetables and also asked

women about weight loss attempts in the previous year (dichotomized by attempted weight loss and no attempted weigh loss). No differences were observed between the sexual orientation groups for either outcome. The three studies provide limited insight regarding eating habits for SMW [10].

Having a more complete picture of what women with different sexual orientations consume would better inform the relationship between nutrient intake and differences in BMI between the two groups. Identifying dietary habits could aid in targeting interventions for SMW who are at a higher risk of obesity: a major risk factor for many adverse health conditions. This study aims to investigate macronutrient intake in SMW and heterosexual women. We hypothesize that there are macronutrient intake differences between SMW and heterosexual women.

3.3 METHODS

3.3.1 Study Design

Data from the **E**pidemiologic **ST**udy of **HE**alth **R**isk in Women (ESTHER) Project conducted in Pittsburgh, PA, from 2003–2006 were used [18-20]. This cross-sectional study includes approximately 1,100 participants, half of whom are SMW. The aim of the ESTHER project was to study risk factors for cardiovascular disease among adult women in the Pittsburgh, PA, area. Participants who identified as sexual minority women or heterosexual women, were age ≥35, were not pregnant, and had no previous history of heart disease (angina, heart attack, or stroke) were eligible for the study. This convenience sample was recruited via newspaper and radio advertisements, community health events, LGBT events/socials, and the University of Pittsburgh

broadcast phone-message system. The study endpoints were collected during two clinic visits where participants completed study questionnaires; a physical activity and medical history interview; a fasting venipuncture; a dual-energy X-ray absorptiometry (DXA) scan of hip, spine, and whole body; and three-day food diaries. The University of Pittsburgh's Institutional Review Board (IRB) reviewed and approved the study. Informed consent was documented via written consent. For their time and participation, participants were reimbursed $50. Funding for the ESTHER Project was provided by the National Heart, Lung, and Blood Institute, R01HL067052.

3.3.2 Sample

The total study sample (n=1,100) was reduced for the current analyses. Participants were not included in these analyses if they were missing key variables: age, height and weight (to calculate BMI), or three-day food diary data. Participants who were underweight or had caloric outliers (less than 500 and greater than 4,500 kilocalories per day) were excluded [21,22]. The data were found to be highly skewed in the distribution of older women with a greater number of older heterosexual women compared with older SMW. Therefore only heterosexuals age <65 were included. There was a disproportionate low prevalence of African-American SMW; therefore, heterosexual African-American women were randomly selected to stay in the sample. The total sample for this analysis was 799 (heterosexual n=368; SMW n=431).

3.3.3 Sexual Orientation

Sexual orientation is defined by the American Psychological Association (APA) as the sex of those to whom one is sexually and romantically attracted [23]. Further, the APA guidelines

define attraction to one's own sex as gay/lesbian, attraction to the other sex as heterosexual, and attraction to both sexes as bisexual. The APA cites research documenting the continuum and fluidity of sexual orientation [23]. The Institute of Medicine highlights that defining "lesbian" is one of the first challenges in studying the minority population [24]. For our research, study participants identified as heterosexual or lesbian. Heterosexuals identified as heterosexual or straight *and* only having male sexual partners since the age of 18 years. SMW, identified as lesbian or bisexual *and* having emotional, physical, and romantic attractions within the past 5 years toward only or primarily women or whose relationships within the past 5 years had been with only or primarily women [19].

3.3.4 Food Diary

Dietary intake data were collected and analyzed using Nutrition Data System for Research (NDSR) software version 2007, developed by the Nutrition Coordinating Center (NCC), University of Minnesota, Minneapolis, MN. The participants recorded their food intake for a total of three days, made up of two weekdays and one weekend day. The NDSR provides a complete nutrient profile for all foods in the database [25-27]. The mean of the three days was calculated for each macronutrient for each participant.

3.3.5 Body Mass Index (BMI)

Body weight for the BMI (kg/m^2) calculation was assessed in kg using a calibrated balance beam scale. Researchers measured standing height in feet and inches using a wall-mounted Harpendon stadiometer. Participants were measured without shoes, and the average of two measures (which

varied <0.5 inches) was used. BMI was collected as a continuous variable and converted into categories as outlined by the World Health Organization (WHO). The categories are: normal weight (BMI = 18.5–24.9); overweight (BMI = 25.0–29.9); and obese (BMI ≥30.0). Obese can be further defined by three classes: obese class I (BMI = 30.00–34.99); obese class II (BMI = 35.00–39.99); obese class III (BMI ≥40.00) [28].

3.3.6 Analytic Approach

Descriptive statistics and comparisons of between-group means were conducted. Categorical variables were created for age and BMI, and all categorical variables were analyzed using chi-squared or Fisher's exact test to compare frequencies. For the comparison of unadjusted means for continuous variables, student's t-tests were used. Multivariate analysis of covariance (MANCOVA) assessed group mean differences after adjusting for highest level of education achieved and parity. The statistically significant threshold was $p<0.05$. All statistical analyses were performed using SPSS (IBM SPSS Statistics 20).

3.4 RESULTS

3.4.1 Participant Characteristics

Participant characteristics are presented in Table 3-1. Just over half the sample identified as being a SMW (53.9%). The sample was primarily Caucasian (92.6%) and not Hispanic (99.4%), highly educated (65.9% completing a bachelor's degree or higher), and having a mean household

income of at least $60,000 (46.0%). Only 35.3% of the total sample was within the normal range for BMI.

When comparing SMW to heterosexual women, there were statistically significant mean group differences. Heterosexual women had a higher rate of parity than SMW (69.0% vs. 26.5%, p<0.001). SMW had a significantly higher mean BMI (29.62 vs. 28.13, p=0.003) and education level (p=0.007) than heterosexual women.

Table 3-1. Participant Characteristics

Variable	Total Sample (N=799)	Heterosexual Women (n=368) n (%)	Sexual Minority Women (n=431) n (%)	Value P
Age, in years				0.613
Mean (SD)	47.59 (7.33)	47.73 (7.64)	47.47 (7.05)	
range	35-64	35-64	35-64	
Age Categories				
35-39	115 (14.4%)	57 (15.5%)	58 (13.5%)	0.298
40-44	184 (23.0%)	83 (22.6%)	101 (23.4%)	
45-49	197 (24.7%)	85 (23.1%)	112 (26.0%)	
50-54	142 (17.8%)	59 (16.0%)	83 (19.3%)	
55-64	161 (20.2%)	84 (22.8%)	77 (17.9%)	
Parity				<0.001
Nulliparous	431 (53.9%)	114 (31.0%)	317 (73.5%)	
Parous	368 (46.1%)	254 (69.0%)	114 (26.5%)	
Race				0.621
Caucasian	740 (92.6%)	339 (92.1%)	401 (93.0%)	
African-American	59 (7.4%)	29 (7.9%)	30 (7.0%)	
Ethnicity				0.720
Not Hispanic or Latino	794 (99.4%)	366 (99.5%)	428 (99.3%)	

Table 3-1. Continued

Variable	Total Sample (N=799)	Heterosexual Women (n=368) n (%)	Sexual Minority Women (n=431) n (%)	Value P
Hispanic or Latino	5 (0.6%)	2 (0.5%)	3 (0.7%)	
BMI kg/m^2				
Mean (SD)	28.93 (7.23)	28.13 (6.44)	29.62 (7.78)	0.003
range	18.55-70.09	18.61-55.54	18.55-70.09	
BMI Categories¥				
Normal	282 (35.3%)	138 (37.5%)	144 (33.4%)	
Overweight	233 (29.2%)	122 (33.2%)	111 (25.8%)	
Obese-Class I	141 (17.6%)	53 (14.4%)	88 (20.4%)	0.010
Obese-Class II	80 (10.0%)	34 (9.2%)	46 (10.7%)	
Obese-Class III	63 (7.9%)	21 (5.7%)	42 (9.7%)	
Total Physical Activity, hours per week	9.3 (11.9) (0-67.17)	8.66 (11.39) (0-58.1)	9.9 (12.3) (0-67.2)	0.139
Government Guidelines for Mod/Vig PA, yes n, %	604, 75.6%	280, 76.1%	324, 75.2%	0.765
Education				
< 12 years	4 (0.5%)	2 (0.5%)	2 (0.5%)	
High school or GED	79 (9.9%)	51 (13.9%)	28 (6.5%)	0.007
Some college	190 (23.8%)	88 (23.9%)	102 (23.7%)	
Bachelors	202 (25.3%)	94 (25.5%)	108 (25.1%)	
Graduate+	324 (40.6%)	133 (36.1%)	191 (44.3%)	
Household Income				
Less than $15,000	60 (7.5%)	30 (8.2%)	30 (7.0%)	
$15,000-$24,999	49 (6.1%)	25 (6.8%)	24 (5.6%)	
$25,000-$39,999	134 (16.8%)	65 (17.7%)	69 (16.0%)	
$40,000-$59,999	174 (21.8%)	79 (21.5%)	95 (22.0%)	0.319
$60,000-$74,999	102 (12.8%)	36 (9.8%)	66 (15.3%)	
$75,000 or more	265 (33.2%)	121 (32.9%)	144 (33.4%)	
Missing	15 (1.9%)	12 (3.3%)	3 (0.7%)	
Medical Insurance				
Yes	734 (91.9%)	338 (91.8%)	396 (91.9%)	0.248
No	63 (7.9%)	29 (7.9%)	34 (7.9%)	

Table 3-1. Continued

Variable	Total Sample (N=799)	Heterosexual Women (n=368) n (%)	Sexual Minority Women (n=431) n (%)	Value P
Missing	2 (0.3%)	1 (0.3%)	1 (0.2%)	
Menopause Status*				0.081
Menopause not suspected	638 (79.8%)	284 (77.2%)	354 (82.1%)	
Menopause	161 (20.2%)	84 (22.8%)	77 (17.9%)	

¥ Normal weight (BMI = 18.5–24.9); overweight (BMI = 25.0–29.9); obese class I (BMI = 30.00–34.99); obese class II (BMI = 35.00–39.99); obese class III (BMI ≥40.00).

* Based on age alone.

3.4.2 Macronutrient Intake by Sexual Orientation

3.4.2.1 Energy Source

The primary energy sources for the total sample, heterosexual women, and SMW are presented in Table 3-2. The mean caloric intake for the total sample was 1,862 kilocalories, and the group differences were statistically significant, with SMW having a higher caloric intake than heterosexual women (1,900 and 1,818, respectively; p=0.024). Even after adjusting for education and parity the SMW still had significantly higher mean caloric intake than heterosexual women (1,910 and 1,805, respectively; p=0.009). The group differences for intake of fat were also statistically significant, with SMW having higher intake of fat per day than heterosexual women (75.6gm and 70.9gm, respectively; p=0.026). The significant differences remained after adjusting for education and parity (70.2 gm/day for SMW; 76.2 gm/day for heterosexual women; p=0.010).

While total protein intake did not differ significantly by sexual orientation group, intake of vegetable protein did differ significantly for the unadjusted mean comparisons with SMW having higher intake than heterosexual women (27.6gm and 25.7gm, respectively; p=0.008). Significant

mean differences for vegetable protein disappeared once the sample was adjusted for education and parity.

Intake of alcohol and percent of total calories from alcohol per day were significantly higher in SMW than heterosexual women (5.9 gm and 4.3 gm of alcohol per day respectively, p=0.023; 2.1% and 1.5% calories per day from alcohol, p=0.022, respectively for SMW and heterosexual women). However, after adjusting for education and parity there were no significant group differences by sexual orientation found (4.4 gm and 5.8 gm of alcohol per day respectively, p=0.090; 1.5% and 2.1% calories per day from alcohol, p=0.076, respectively for SMW and heterosexual women)

3.4.2.2 Fat and Cholesterol

Daily fat and cholesterol intake for the total sample, heterosexual women, and SMW are presented in Table 3-3. The group differences were statistically significant for two types of fat: total monounsaturated fatty acids and total polyunsaturated fatty acids. The group differences remained statistically significant for the unadjusted, and adjusted means with SMW having higher intake of fats. Total saturated fatty acid intake was higher among SMW than heterosexual women. The group means were only borderline statistically significant (p=0.058) but then significant after adjusting for education and parity (p=0.013). For both of the significant comparisons, the SMW had higher intakes than the heterosexual women.

3.4.2.3 Carbohydrates

As noted in Table 3-4, total daily carbohydrate intake did not differ significantly by sexual orientation. However, when investigating the group differences by components of carbohydrates

(Table 3-4), intake of galactose was significantly higher for SMW than heterosexual women (0.5gm and 0.4gm, respectively; p=0.043) for the unadjusted sample. After adjusting for education and parity, fructose and glucose were significantly higher among SMW than heterosexual women (p=0.010 and p=0.009, respectively).

3.4.2.4 Fiber

Table 3-5 displays the daily fiber intake for the total sample, heterosexual women, and SMW. The total dietary fiber, soluble dietary fiber, and insoluble dietary fiber intakes were similar across the sexual orientation groups. We did not find significant group differences for the unadjusted, or adjusted, sample.

Table 3-2. Daily Energy Sources

Energy Source	Unadjusted mean (SD) range				Adjusted for Education Level and Parity Adjusted mean (SE)		
	Total Sample (N=799)	**Heterosexual Women (n=368)**	**Sexual Minority Women (n=431)**	**P**	**Heterosexual Women (n=368)**	**Sexual Minority Women (n=431)**	**P**
Energy (kilocalories)	1,861.91 (513.68) 529.75-3,667.35	1,817.50 (507.87) 529.75-3,463.08	1,899.82 (516.16) 699.94-3,667.35	0.024*	1,805.14 (28.26)	1,910.38 (25.91)	0.009*
Total Fat g	73.43 (29.95) 11.54-191.68	70.88 (28.94) 11.54-191.68	75.61 (30.65) 16.33-186.10	0.026*	70.15 (1.65)	76.22 (1.51)	0.010*
Total Carbohydrate g	225.52 (70.45) 54.38-492.01	222.54 (70.55) 56.67-477.68	228.07 (70.35) 54.38-492.01	0.269	220.68 (3.89)	229.65 (3.56)	0.105
Available Carbohydrate g	207.13 (67.18) 37.98-474.94	204.52 (67.29) 48.75-458.43	209.37 (67.09) 37.98-474.94	0.309	202.37 (3.70)	211.20 (3.39)	0.094
Total Protein g	75.02 (22.61) 13.92-174.88	73.88 (22.78) 17.3-174.88	75.99 (22.44) 13.92-156.56	0.188	74.13 (1.24)	75.79 (1.14)	0.349
Animal Protein g	48.15 (21.30) 2.09-157.41	48.06 (21.00) 6.22-157.41	48.24 (21.57) 2.09-122.30	0.904	47.91 (1.18)	48.36 (1.08)	0.788
Vegetable Protein g	26.74 (10.13) 3.78-75.58	25.71 (9.85) 3.78-75.58	27.62 (10.29) 4.94-72.39	0.008*	26.12 (0.55)	27.27 (0.50)	0.142
Alcohol g	5.16 (10.57) 0-89.73	4.26 (9.07) 0-64.92	5.93 (11.66) 0-89.73	0.023*	4.41 (0.58)	5.81 (0.53)	0.090
% calories from fat	34.51 (8.14) 6.65-73.50	34.17 (8.04) 6.65-59.81	34.79 (8.23) 9.65-73.50	0.281	34.10 (0.45)	34.85 (0.41)	0.240
% calories from carbohydrate	49.09 (9.44) 11.08-80.24	49.54 (9.19) 11.08-80.24	48.70 (9.64) 13.55-74.28	0.212	49.43 (0.52)	48.79 (0.48)	0.388

Table 3-2. Continued

Energy Source	Unadjusted mean (SD) range				Adjusted for Education Level and Parity Adjusted mean (SE)		
	Total Sample (N=799)	**Heterosexual Women (n=368)**	**Sexual Minority Women (n=431)**	**P**	**Heterosexual Women (n=368)**	**Sexual Minority Women (n=431)**	**P**
% calories from protein	16.63 (4.08) 5.88-44.61	16.80 (4.24) 5.88-44.61	16.48 (3.94) 7.75-36.58	0.269	16.97 (0.22)	16.34 (0.21)	0.048*
% calories from alcohol	1.82 (3.4) 0-26.46	1.52 (3.12) 0-21.64	2.08 (3.84) 0-26.46	0.022*	1.56 (0.19)	2.05 (0.18)	0.076

* <0.05

Table 3-3. Daily Fat and Cholesterol Intake

Fat and Cholesterol	Unadjusted mean (SD) range				Adjusted for Education Level and Parity Adjusted mean (SE)		
	Total Sample (N=799)	**Heterosexual Women (n=368)**	**Sexual Minority Women (n=431)**	**P**	**Heterosexual Women (n=368)**	**Sexual Minority Women (n=431)**	**P**
Cholesterol mg	240.65 (139.64) 1.65-850.50	234.54 (129.42) 17.71-850.50	245.87 (147.75) 1.65-837.60	0.249	232.64 (7.70)	247.49 (7.06)	0.176
Total Saturated Fatty Acids g	24.67 (11.49) 2.65-75.72	23.84 (11.18) 2.65-73.60	25.38 (11.71) 4.63-75.72	0.058	23.47 (0.63)	25.70 (0.58)	0.013*

Table 3-3. Continued

Total Monounsaturated Fatty Acids g	27.44 (11.81) 2.24-72.85	26.53 (11.18) 2.24-67.78	28.22 (12.29) 4.53-72.85	0.043*	26.30 (0.65)	28.42 (0.60)	0.022*
Total Polyunsaturated Fatty Acids g	15.66 (7.74) 2.35-57.68	14.19 (7.43) 2.35-45.19	16.23 (7.95) 2.60-57.68	0.024*	14.91 (0.43)	16.29 (0.39)	0.023*
Total Trans-Fatty Acids g	4.10 (2.64) 0.01-18.36	4.05 (2.68) 0.01-16.40	4.15 (2.61) 0.14-18.36	0.593	3.95 (0.14)	4.23 (0.13)	0.172
Omega-3 Fatty Acids g	1.78 (1.33) 0.20-16.00	1.79 (1.43) 0.22-12.58	1.77 (1.24) 0.20-16.00	0.901	1.80 (0.07)	1.76 (0.07)	0.720
% calories from SFA	11.56 (3.54) 1.52-28.08	11.43 (3.54) 1.52-22.75	11.66 (3.54) 3.06-28.08	0.366	11.34 (0.20)	11.74 (0.18)	0.150
% calories from MUFA	12.88 (3.60) 1.29-36.86	12.79 (3.45) 1.29-24.19	12.96 (3.72) 3.36-36.86	0.530	12.79 (0.20)	12.96 (0.18)	0.556
% calories from PUFA	7.37 (2.66) 2.08-20.22	7.24 (2.62) 2.16-19.69	7.48 (2.69) 2.08-20.22	0.186	7.27 (0.15)	7.46 (0.14)	0.350
Polyunsaturated to Saturated Fat Ratio	0.75 (0.39) 0.13-3.95	0.76 (0.42) 0.15-3.95	0.75 (0.36) 0.13-2.66	0.928	0.77 (0.02)	0.74 (0.02)	0.453

*** <0.05

Table 3-4. Daily Carbohydrate Intake

Carbohydrates	Unadjusted mean (SD) range				Adjusted for Education Level and Parity Adjusted mean (SE)		
	Total Sample (N=799)	**Heterosexual Women (n=368)**	**Heterosexual Women (n=368)**	**Heterosexual Women (n=368)**	**Heterosexual Women (n=368)**	**Sexual Minority Women (n=431)**	**P**
Total Sugars g	100.23 (43.62) 13.84-310.35	99.62 (41.86) 20.12-310.35	100.76 (45.11) 13.84-283.27	0.713	97.82 (2.40)	102.30 (2.20)	0.189
Added Sugars g	64.25 (40.22) 2.27-279.58	63.71 (38.67) 2.27-279.58	64.70 (41.54) 5.09-260.00	0.728	61.21 (2.18)	66.83 (2.00)	0.070
Fructose g	19.11 (13.40) 0.92-133.69	18.24 (12.57) 0.92-133.69	19.85 (14.05) 1.93-121.26	0.089	17.67 (0.74)	20.35 (0.67)	0.010*
Galactose g	0.48 (0.78) 0-9.08	0.42 (0.54) 0-3.89	0.53 (0.94) 0-9.08	0.043*	0.43 (0.04)	0.53 (0.04)	0.093
Glucose g	20.89 (12.69) 1.38-116.64	20.11 (11.50) 2.54-112.35	21.56 (13.60) 1.38-116.64	0.101	19.49 (0.69)	22.09 (0.64)	0.009*
Lactose g	13.02 (9.84) 0.01-60.19	13.70 (10.26) 0.01-56.05	12.44 (9.44) 0.05-60.19	0.073	13.75 (0.54)	12.40 (0.50)	0.080
Maltose g	3.55 (2.83) 0.12-28.50	3.65 (3.17) 0.27-28.50	3.47 (2.51) 0.12-17.22	0.373	3.56 (0.16)	3.54 (0.14)	0.929
Sucrose g	43.18 (25.11) .3.7-156.55	43.50 (24.95) 3.91-156.55	42.91 (25.27) 3.37-138.84	0.742	42.93 (1.39)	43.39 (1.27)	0.816
Starch g	95.10 (36.52) 6.91-250.97	93.75 (38.29) 8.72-236.05	96.25 (34.94) 6.91-251.97	0.336	93.28 (2.02)	96.65 (1.85)	0.240

*** <0.05

Table 3-5. Daily Fiber Intake

Fiber	Unadjusted mean (SD) range				Adjusted for Education Level and Parity Adjusted mean (SE)		
	Total Sample (N=799)	Heterosexual Women (n=368)	Heterosexual Women (n=368)	Heterosexual Women (n=368)	Heterosexual Women (n=368)	Sexual Minority Women (n=431)	P
Total Dietary Fiber g	18.21 (7.41) 19.3-50.22	17.81 (7.12) 2.26-49.32	18.56 (7.65) 1.93-50.22	0.150	18.10 (0.40)	18.31 (0.37)	0.716
Soluble Dietary Fiber g	4.75 (1.92) 0.66-12.98	4.69 (1.89) 0.81-12.81	4.80 (1.94) 0.66-12.98	0.413	4.76 (0.10)	4.73 (0.10)	0.860
Insoluble Dietary Fiber g	13.26 (5.83) 1.27-39.89	12.93 (5.53) 1.46-35.10	13.54 (6.07) 1.27-39.89	0.136	13.14 (0.32)	13.36 (0.29)	0.618

* <0.05

3.5 DISCUSSION

To our knowledge this is the first study to compare the dietary intakes of SMW and heterosexual women at this level of macronutrient detail. The ESTHER project included a three-day food diary permitting the assessment of the nutrient profile for all foods in the NDSR database [25-27]. Macronutrient differences between sexual orientation groups were identified. SMW had statistically significantly higher caloric intake and higher intake of fat. After adjusting for education and parity the SMW still had higher caloric intake and higher intake of fat. SMW had statistically significant higher intake of alcohol than the heterosexual women but after adjusting for education and parity there were no differences by sexual orientation.

Existing research reports disparities in body mass index of women by sexual orientation but the research into dietary intake by sexual orientation is limited [8-17]. Studies that have investigated dietary discrepancies by sexual orientation in women have not had the advantage of a daily food diary like the ESTHER project. Other researchers have relied on general reports of consumption such as daily value of fruit and vegetable servings estimated by <2 servings; 2–3 servings; 4–5 servings; and ≥6 servings [10,15]. One study researching dietary differences by sexual orientation did not include specific macronutrient groups, rather asked participants about intake of red meat, if the percent of daily caloric intake contributed by fat was more than 30%, and if a low fat diet or a vegetarian diet was held over the past year [17]. The ESTHER project was able to collect and analyze very specific nutrient components.

During this study, we identified dietary differences by sexual orientation that may help understand BMI differences between these groups of women. The overall caloric intake was higher in SMW than heterosexual women, even after adjusting for education and parity. The women from the ESTHER project consumed an average of 1,862 kilocalories per day and the SMW consumed about 82 more kilocalories per day than the heterosexual women for the unadjusted sample (1,899.82 and 1,817.50 kilocalories per day respectively) and about 105 more kilocalories per day than the heterosexual women after adjusting for education and parity (1,910.38 and 1,805.14 kilocalories per day respectively). Estimating that 3,500 kcal represents about a pound of body weight, over a year, the difference noted above equals about eight and a half pounds for the sample and nearly 11 pounds after adjusting for education and parity. In the US, adult women age ≥20 consume about 1,877 kilocalories per day, and among women age 40–59, 1,828 kilocalories per day [29]. The consumption of fat grams per day was significantly higher among SMW than heterosexual women in the ESTHER sample ($p=0.026$ and $p=0.010$, unadjusted and adjusted, respectively). SMW consumed 4.73 more grams of fat per day than heterosexual women for the unadjusted sample and 6.07gm for the adjusted estimate.

Consistent with other research, the ESTHER sample showed higher alcohol consumption among SMW than heterosexual women [12,15,30-34]. The grams of alcohol and percent of calories from alcohol were statistically higher among SMW than heterosexual women. However, after adjusting for education and parity no group differences were identified. Adult women in the US consume about 53 kilocalories per day from alcohol, whereas the ESTHER sample consumed about 34 kilocalories per day from alcohol (27.6 kilocalories per day among heterosexual women; 39.5 kilocalories per day among SMW for the unadjusted sample and 28.1 kilocalories

per day among heterosexual women; 39.2 39.5 kilocalories per day among SMW for the adjusted sample) [35,36].

The percent of calories from fat, carbohydrates, and protein was not statistically different by sexual orientation in the ESTHER sample. After adjusting for education and parity, the SMW had slightly lower contributions of their calories per day from protein than heterosexual women ($p=0.048$). The ESTHER sample consumed about 34.5% calories from fat, 49.0% calories from carbohydrates, and about 16.6% calories from protein. Adult women in the US consume a slightly smaller percent of fat, a slightly higher percent from carbohydrates, and a slightly smaller percent of protein (32.8%, 51.6%, and 15.1%, respectively) than the ESTHER sample [29]. The ESTHER sample was within the recommended macronutrient proportions for adults, as advised by dietary guidelines for Americans [37].

Simply defining a sexual orientation group is a challenge for researchers, as noted in *The Health of Lesbian, Gay, Bisexual, and Transgender People: building a Foundation for Better Understanding* [16] and makes it difficult to compare studies and generalize results beyond the sample being studied. The ESTHER sample included women who identified as heterosexual or SMW; the sample did not include women who reported primary relationships with both men and women. Valanis and colleagues [15], which utilized a population-based study, has the advantage of a large population in their analysis. Their research showed lower 3 month habits of fruit and vegetable intake among SMW than heterosexual women. However, the way sexual orientation was categorized makes it difficult to generalize the findings to specific sexual orientation groups. The study combines bisexual women, adult lesbians, and lifetime lesbians into a single group to compare with heterosexuals. The study included older women age 50–79, whereas the ESTHER project included younger women (age 35-64).

To evaluate energy imbalance, in addition to determining dietary intake, we estimated physical activity. Our assessments of physical activity were broadly measured in two ways. One way was the total hours per week of physical activity. The second was comparing hours per week of moderate and vigorous physical activity to meeting government guidelines on moderate and vigorous physical activity. There are certainly more specific measures of physical activity. The ESTHER data have been extensively compared and no differences by sexual orientation have been revealed [38].

The dietary data from the ESTHER project are limited by self-report, and by only three days of dietary tracking. The daily report reduces recall bias, but reporting bias may still be possible and the generalizability of a three-day record could be challenged. The Nutrition Data System for Research (NDSR) software was the 2007 version, so all food formulas are tied to that version of the software. While newer NDSR software exists, the food formulas may have changed, so it is not appropriate to update or re-run the data with newer software. The BMI differences in the ESTHER sample were statistically significant by sexual orientation, but the mean BMI for both SMW and heterosexual women were within the Overweight category of BMI groupings. Because of the cross-sectional design, the ESTHER study cannot point to any causal relationships between dietary intake and BMI; these data are limited to observations of dietary intake during a three-day period.

The aim of the ESTHER project was to study risk factors of cardiovascular disease among adult women in Pittsburgh, PA. The SMW had a higher BMI than heterosexual women, and there were no differences in physical activity by sexual orientation. While statistically significant differences were identified between sexual orientation groups, the differences may not be clinically meaningful. The total energy intake and grams of fat differences are 82.0 kilocalories

and 4.7 grams, respectively for the unadjusted sample. This difference may not be meaningful to clinicians treating women through primary care or weight management programs. The energy intake and total fat is about equal to two Hershey Special Dark Mini bars (88 calories, 5.2 grams of fat) or one mini Mounds bar (80 calories, 4.5 grams of fat) per day. Over time, the intake variance would elicit BMI differences by sexual orientation.

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4.0 DIETARY MEDIATORS OF THE RELATIONSHIP BETWEEN THE SEXUAL ORIENTATION OF WOMEN AND BODY MASS INDEX

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4.1 ABSTRACT

Background and Objective: Sexual minority women (SMW) have a higher body mass index (BMI) than heterosexual women, and also differ in dietary intake. The aim of our study was to test the hypothesis that caloric intake and macronutrient components partially mediate the relationship between the sexual orientation of women and BMI.

Methods: Dietary intake data collected via a three-day food diary as part of the **E**pidemiologic **ST**udy of **HE**alth **R**isk in Women (ESTHER) Project (Pittsburgh, PA) were used for this secondary data analysis. The sample included 431 SMW and 368 heterosexual women age 35 to 64 years. Dietary analysis was performed with the Nutrition Data System for Research (NDSR) software version 2007. Mediation models were estimated using the PROCESS macro in SPSS (Hayes mediation approach). Total caloric intake was tested as mediator; then macronutrients (mean daily grams of each: fat, carbohydrates, protein, and alcohol) were tested as parallel mediators. Models were tested without controlling for covariates and then again controlling for covariates (age, education, smoking status, and physical activity).

Results: Sexual orientation was associated with BMI both directly and indirectly through total caloric intake, without covariates and with covariates held constant. In the parallel mediating model without covariates and with covariates held constant, only fat intake showed partial mediation between the sexual orientation of women and BMI; sexual orientation was statistically related to BMI.

Conclusion: This is the first study to use three-day food diary data to explore the relationship between the sexual orientation of women and BMI and potential dietary mediators. Results

indicated that total caloric intake and dietary components (fat intake) statistically mediate the association between the sexual orientation of women and BMI.

4.2 INTRODUCTION

Obesity rates are higher among sexual minority women (SMW) than heterosexual women [1-9]. This is important because obesity is a significant risk factor for cardiovascular disease (CVD), the leading cause of death among women, and obesity is preventable. [10]. The Institute of Medicine's (IOM's) first report on the health of lesbian, gay, bisexual, and transgender people specifically highlights the issue of increased obesity among SMW. Theories citing reasons why obesity is associated with SMW include obesity is associated with minority stress exposure; SMW have less body dissatisfaction than heterosexual women; differences in exercise patterns between SMW and heterosexual women; and childhood sexual abuse (CSA), a risk factor for multiple deleterious health outcomes, is more prevalent among SMW [11].

There is a higher prevalence of mental health disorders among sexual orientation minorities than heterosexuals [12]. The minority stress theory model hypothesizes that the hostile and stressful environment created by stigma, prejudice, and discrimination against SMW, causes mental health issues, and this may explain the greater prevalence of mental health disorders among sexual orientation minorities [12]. The impact of the environment, as outlined in the minority stress theory model, could also yield a greater risk for obesity. Research has shown poorer mental and physical health, higher rates of smoking, higher alcohol consumption, and higher rates of substance abuse in SMW than heterosexual women [5,8,13-25]. The link between the minority stress theory and obesity has been hypothesized but not fully researched.

A positive body image of one's self, and the preference for their partner's body type to be larger, has been suggested as a theory as to why SMW have higher rates of obesity than heterosexual women [11]. Research studies have used a number of approaches to investigate the association of obesity with body image, esteem, appearance, and preference for partner's body type with inconsistent findings.

Body image satisfaction has been studied among SMW, and research supports SMW having higher body esteem, than heterosexual women [26-30]. Alternatively, Aaron and colleagues (2005) found that overweight SMW are not satisfied with their body shape or size. For example, 65% of the sample (n=144 SMW) was dissatisfied with their body shape, 62% were dissatisfied with their weight, and 72% reported behavior modifications to reduce their weight over the past year [31]. Some research supports the belief that SMW have less concern for their physical appearance and have a significantly higher ideal weight for themselves than heterosexual women [29,32]. When viewing images of women to assess attractive body types, SMW preferred heavy-figured images and showed preferences for significantly higher body mass index (BMI) images than heterosexual women [33,34]. Heffernan [35] suggests SMW conceptualize physical attractiveness related to physical condition in terms of functional quality rather than "looks". However, some researchers found no significant differences between SMW and heterosexual women in weight and views on appearance [36,37]. Conformity to cultural expectations of ideal body image has yielded mixed results during research with SMW; for example, some research shows SMW conform to society's ideal thinness, while other research suggests SMW do not adhere to societal standards of appearance [4,36,38]. It has also been suggested that SMW internalize cultural standards, while some research suggests that SMW have lower levels of internalization than heterosexual women. Others have concluded that SMW do internalize body

expectations, but keep silent for fear of judgment within their community for adhering to cultural standards [26,39].

Exercise pattern differences between SMW and heterosexual women have been highlighted as a reason that SMW have greater rates of obesity [11] although there is a dearth of evidence to support this theory. Research comparing SMW and heterosexual women show an insufficient level of physical activity in both groups of women [1,8,13]. Some research suggests that SMW, as compared with heterosexual women, participate in more frequent strenuous physical activity and are more likely to participate in physical activity at least weekly [5,40]. The idea that SMW have higher BMI because of higher physical fitness (e.g., muscle mass) is not supported in the literature [41].

The final theory associating sexual orientation and obesity from the IOM report is a history of CSA [11]. Two studies involving SMW have reported an association. Aaron and Hughes [42] interviewed a large sample of SMW (n=416) and found statistically significant differences between subgroups. Specifically, mean BMI was statistically significantly higher among women who reported CSA than those who did not. CSA was statistically significantly related to BMI; after adjusting for sociodemographic variables, women reporting CSA were more likely to be obese or severely obese. Smith and colleagues [43] identified female sexual orientation and intrafamilial CSA as independent predictors of obesity.

Energy imbalance is at the crux of obesity yet the IOM report does not discuss energy intake. There is limited research into the dietary differences among women by sexual orientation. Using the Food Frequency Questionnaire, one study found SMW had lower intake of fruits and vegetables than heterosexual women, and two studies did not find significant differences in dietary intake [3,8,40]. A study of mean dietary intake using three-day food diary data compared

dietary composition between SMW and heterosexual women. SMW had significantly higher caloric intake, fat grams, alcohol grams, total monounsaturated fatty acid grams, total polyunsaturated fatty acid grams, and vegetable protein than heterosexual women [9].

As noted above, research involving SMW and weight has consistently found that SMW have higher rates of obesity than heterosexual women [1-9]. Nevertheless, there is a dearth of research examining energy intake and physical activity as causes of differences in BMI. Factors influencing the relationship between the sexual orientation of women and BMI should be investigated. Boehmer and Bowen [3] explored energy intake and energy expenditure as mediators of the relationship between the sexual orientation of women and BMI. These investigators used data from the California Women's Health Study (2001-2005) on energy intake from average daily servings of fruits/vegetables and weight loss attempts (yes/no) in the previous year. The mediation modeling followed the Baron and Kenny [44] approach. A direct association between the sexual orientation of women and BMI was found, but no indirect effects were supported; energy intake and energy expenditure were not found to statistically mediate the relationship between the sexual orientation of women and BMI. We suggest that an alternative analytic approach to mediation may yield different indirect pathway results, and that more specific variables for dietary intake would further the research. Understanding more about the potential mediators between the sexual orientation of women and BMI could enhance public health efforts to reduce and prevent obesity among SMW. This study aims to test the hypothesis that caloric intake and macronutrient components mediate the relationship between the sexual orientation of women and BMI.

4.3 METHODS

4.3.1 Study Design and Sample

The study design and sample has been published previously [9]. In brief, data were from the **E**pidemiologic **ST**udy of **HE**alth **R**isk in Women (ESTHER) Project conducted in Pittsburgh, PA, from 2003-2006 [9,43,45,46]. The aim of the cross-sectional ESTHER project was to study risk factors for cardiovascular disease among adult women in the Pittsburgh, PA, area. Participants who identified as SMW or heterosexual women, were age ≥35, were not pregnant, and had no previous history of heart disease (angina, heart attack, or stroke) were eligible for the study. The convenience sample was recruited via newspaper and radio advertisements, community health events, LGBT events/socials, and the University of Pittsburgh broadcast phone-message system.

Data were collected during two clinic visits where ESTHER participants completed study questionnaires; a physical activity and medical history interview; a fasting venipuncture; a dual-energy X-ray absorptiometry (DXA) scan of hip, spine, and whole body; and three-day food diaries. The women completed about five sets of questionnaires with an excess of 250 questions and included questions about behavioral, psychosocial, sociodemographic, health history, and clinical questions. Among the questions, women were asked if they had ever been diagnosed with depression or anxiety.

The University of Pittsburgh's Institutional Review Board (IRB) reviewed and approved the study. Informed consent was documented via written authorization. For their time and

participation, the women were reimbursed $50. Funding for the ESTHER Project was provided by the National Heart, Lung, and Blood Institute, R01HL067052.

The ESTHER study sample was reduced to 799 (heterosexual n=368; SMW n=431) for this analysis. The reduction in the sample size was based on missing key variables: age, height, weight, or three-day food diary data. Participants who were underweight or had caloric outliers (less than 500 and greater than 4,500 kilocalories per day) were excluded [47,48]. The data were highly skewed, with greater numbers of older heterosexual women compared with older SMW; therefore, only heterosexuals age less than 65 years were included. Also, heterosexual African-American women were randomly selected to stay in the sample, as there was a disproportionate low prevalence of African-American SMW.

4.3.2 Dependent Variable

The dependent variable in the mediation model was continuous BMI. As described in previous research [9], BMI (kg/m^2) was assessed in kg using a calibrated balance beam scale. Researchers measured standing height in feet and inches using a wall-mounted Harpendon stadiometer, then converted to meters for BMI calculation.

4.3.3 Independent Variable

Sexual orientation was included as the independent variable in the mediation models (heterosexual women coded 0; SMW coded as 1). Participants identifying as heterosexual or straight *and* only having male sexual partners since the age of 18 years were grouped as heterosexual women. SMW were women who identified as lesbian or bisexual *and* having

emotional, physical, and romantic attractions within the past five years toward only or primarily women, or whose relationships within the past five years had been with only or primarily women [45].

4.3.4 Covariates

Covariates were selected based on common risk factors for obesity, that is, age, education representing socioeconomic stats, smoking status, and physical activity (meeting government guidelines for moderate and vigorous physical activity). Smoking status was included because smoking has been associated with both lower BMI (appetite reduction) and increase BMI (heavy smoking), as well as having impacts on the metabolic syndrome [49].

Race was not included as a covariate because the analysis sample was already adjusted due to the disproportionately low prevalence of African-American SMW. Age in years was treated as a continuous variable. Highest level of education achieved, and smoking status were categorized as shown in Table 4-1. Meeting national guidelines for moderate and vigorous physical activity was a dichotomous variable (yes/no). Women were coded as meeting the guideline if they self-reported weekly participation in at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic physical activity. Combinations of moderate and vigorous physical activity were combined using the guidelines' recommendation of 1 minute of vigorous activity is equal to 2 minutes of moderate physical activity. Previous research among SMW used the same approach to combine moderate and vigorous physical activity, and assess if government guidelines were met [50,51].

4.3.5 Mediators

The mediation models were evaluated (Figure 4-1) both without covariates included and then with covariates included. Total caloric intake was assessed as a mediator, then a parallel mediation model was tested using individual macronutrients (mean daily grams of fat, carbohydrates, protein, and alcohol) simultaneously as mediators. The parallel mediation model estimate did not include total calories because of redundancy with the individual macronutrient components. The dietary intake data were collected and analyzed using Nutrition Data System for Research (NDSR) software version 2007, developed by the Nutrition Coordinating Center (NCC), University of Minnesota, Minneapolis, MN. The participants recorded their food intake for a total of three days—two weekdays and one weekend day. The NDSR provides a complete nutrient profile for all foods in the database [52-54]. The mean of the three days was calculated for each macronutrient for each participant.

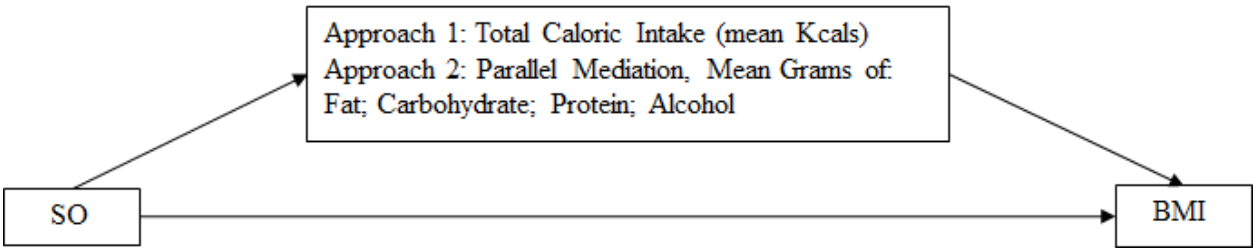

Figure 4-1. Estimated Mediation Models

SO=sexual orientation; BMI= body mass index (kg/m^2)

4.3.6 Analytic Approach

The Hayes mediation modeling approach was followed and the PROCESS macro (versions 2.12.1 and 2.15), an ordinary lease squares path analysis, was utilized [55]. All statistical analyses were performed using SPSS (IBM SPSS Statistics versions 20 and 23). The mediation models aimed to assess the extent to which the mediation variables accounted for the relationship between the sexual orientation of women and BMI. It should be noted that this mediation approach does not require a causal steps approach (e.g. Baron and Kenny [44]), rather the independent variable, potential mediator(s), dependent variable, and covariates are all entered into the model at once. The stepwise approach to mediation modeling requires an association between the predictor and outcome variables but researchers have argued that this is not necessary [55,56]. The traditional approaches to mediation modeling also use the normal theory test for indirect effects (e.g. Sobel test) which can be sensitive to sampling distribution and has low power and generates confidence intervals that are arguably less accurate than other approaches [56]. Software packages have computing power to randomly select and statically 'resample' the data any number of times (we used 10,000 times) to produce a confidence interval for the indirect effects. More information about the differences in the causal steps approach and Hayes mediation can be found in, "*Beyond Baron and Kenny: statistical mediation analysis in the new millennium*" [57].

4.4 RESULTS

4.4.1 Participant Characteristics

Participant characteristics are presented in Table 4-1. Just over half the sample identified as being a SMW (53.9%). The sample was primarily Caucasian (92.6%) and not Hispanic (99.4%), highly educated (65.9% completing a bachelor's degree or higher), and having a mean household income of at least $60,000 (46.0%). Only 35.3% of the total sample was within the normal range for BMI.

When comparing SMW to heterosexual women, there were statistically significant mean group differences. Heterosexual women had a higher rate of parity than SMW (69.0% vs. 26.5%, $p<0.001$). SMW had a significantly higher mean BMI (29.62 kg/m^2 vs. 28.13 kg/m^2, $p=0.003$) and education level ($p=0.007$) than heterosexual women. SMW had higher mean daily caloric intake, fat intake, and alcohol intake then heterosexual women (all $p<0.05$). The SMW had significantly higher rates of depression history ($p<0.001$) but only borderline significantly higher rates of anxiety history ($p=0.056$) as compared with the heterosexual women. Smoking status and number of alcoholic drinks per month were significantly different between the sexual orientation groups.

Table 4-1. Participant Characteristics

Variable	Total Sample (N=799)	Heterosexual Women (n=368) n (%)	Sexual Minority Women (n=431) n (%)	Value P
Age, Years				
Mean (SD)	47.59 (7.33)	47.73 (7.64)	47.47 (7.05)	0.613
Range	35-64	35-64	35-64	
Age Categories				
35-39	115 (14.4%)	57 (15.5%)	58 (13.5%)	
40-44	184 (23.0%)	83 (22.6%)	101 (23.4%)	
45-49	197 (24.7%)	85 (23.1%)	112 (26.0%)	0.298
50-54	142 (17.8%)	59 (16.0%)	83 (19.3%)	
55-64	161 (20.2%)	84 (22.8%)	77 (17.9%)	
Parity				
Nulliparous	431 (53.9%)	114 (31.0%)	317 (73.5%)	<0.001
Parous	368 (46.1%)	254 (69.0%)	114 (26.5%)	
Race				
Caucasian	740 (92.6%)	339 (92.1%)	401 (93.0%)	0.621
African-American	59 (7.4%)	29 (7.9%)	30 (7.0%)	
Ethnicity				
Not Hispanic or Latino	794 (99.4%)	366 (99.5%)	428 (99.3%)	0.720
Hispanic or Latino	5 (0.6%)	2 (0.5%)	3 (0.7%)	
BMI kg/m^2				
Mean (SD)	28.93 (7.23)	28.13 (6.44)	29.62 (7.78)	0.003
Range	18.55-70.09	18.61-55.54	18.55-70.09	
BMI Categories¥				
Normal	282 (35.3%)	138 (37.5%)	144 (33.4%)	
Overweight	233 (29.2%)	122 (33.2%)	111 (25.8%)	0.010
Obese-Class I	141 (17.6%)	53 (14.4%)	88 (20.4%)	
Obese-Class II	80 (10.0%)	34 (9.2%)	46 (10.7%)	
Obese-Class III	63 (7.9%)	21 (5.7%)	42 (9.7%)	
Total Physical Activity, Hours per Week	9.3 (11.9) (0-67.17)	8.66 (11.39) (0-58.1)	9.9 (12.3) (0-67.2)	0.139

Table 4.-1. Continued

Variable	Total Sample (N=799)	Heterosexual Women (n=368) n (%)	Sexual Minority Women (n=431) n (%)	Value P
Government Guidelines for Mod/Vig PA, Yes n, %	604, 75.6%	280, 76.1%	324, 75.2%	0.765
Education				0.007
< 12 years	4 (0.5%)	2 (0.5%)	2 (0.5%)	
High School or GED	79 (9.9%)	51 (13.9%)	28 (6.5%)	
Some College	190 (23.8%)	88 (23.9%)	102 (23.7%)	
Bachelors	202 (25.3%)	94 (25.5%)	108 (25.1%)	
Graduate+	324 (40.6%)	133 (36.1%)	191 (44.3%)	
Household Income				0.319
Less than $15,000	60 (7.5%)	30 (8.2%)	30 (7.0%)	
$15,000-$24,999	49 (6.1%)	25 (6.8%)	24 (5.6%)	
$25,000-$39,999	134 (16.8%)	65 (17.7%)	69 (16.0%)	
$40,000-$59,999	174 (21.8%)	79 (21.5%)	95 (22.0%)	
$60,000-$74,999	102 (12.8%)	36 (9.8%)	66 (15.3%)	
$75,000 or more	265 (33.2%)	121 (32.9%)	144 (33.4%)	
Missing	15 (1.9%)	12 (3.3%)	3 (0.7%)	
Medical Insurance				0.248
Yes	734 (91.9%)	338 (91.8%)	396 (91.9%)	
No	63 (7.9%)	29 (7.9%)	34 (7.9%)	
Missing	2 (0.3%)	1 (0.3%)	1 (0.2%)	
Menopause Status*				0.081
Menopause Not Suspected	638 (79.8%)	284 (77.2%)	354 (82.1%)	
Menopause	161 (20.2%)	84 (22.8%)	77 (17.9%)	
Self-report History of Depression	316 (39.5%)	121 (32.9%)	195 (45.2%)	<0.001
Missing	3 (0.4%)	2 (0.5%)	1 (0.2%)	
Self-report History of Anxiety	204 (25.5%)	82 (22.3%)	122 (28.3%)	0.056
Missing	4 (0.5%)	3 (0.8%)	1 (0.2%)	
Smoking Status				<0.001
Never	415 (51.9%)	221 (60.1%)	194 (45.0%)	

Table 4-1. Continued

Variable	Total Sample (N=799)	Heterosexual Women (n=368) n (%)	Sexual Minority Women (n=431) n (%)	Value P
Former	296 (37.0%)	120 (32.6%)	176 (40.8%)	
Current	88 (11.0%)	27 (7.3%)	61 (14.2%)	
Calories Per Day, kcals	1,861.91 (513.68) 529.75-3,667.35	1,817.50 (507.87) 529.75-3,463.08	1,899.82 (516.16) 699.94-3,667.35	0.024***
Fat Intake Per Day, g	73.43 (29.95) 11.54-191.68	70.88 (28.94) 11.54-191.68	75.61 (30.65) 16.33-186.10	0.026
Carbohydrate Intake Per Day, g	225.52 (70.45) 54.38-492.01	222.54 (70.55) 56.67-477.68	228.07 (70.35) 54.38-492.01	0.269
Protein Intake Per Day, g	75.02 (22.61) 13.92-174.88	73.88 (22.78) 17.3-174.88	75.99 (22.44) 13.92-156.56	0.188
Alcohol Intake Per Day, g	5.16 (10.57) 0-89.73	4.26 (9.07) 0-64.92	5.93 (11.66) 0-89.73	0.023
Number of Alcoholic Drinks per Month				
Mean (SD)	8.2 (16.1)	6.9 (13.0)	9.3 (18.3)	0.034
Range	0-216.7	0-91	0-216.7	
Missing	23 (2.9%)	14 (3.8%)	9 (2.1%)	

¥ Normal weight (BMI = 18.5-24.9); overweight (BMI = 25.0-29.9); obese-class I (BMI = 30.00-34.99); obese-class II (BMI = 35.00-39.99); obese-class III (BMI ≥40.00).

* Based on age alone (55 years).

4.4.2 Mediation

4.4.2.1 Covariates in the Models

Both modeling approaches, total caloric intake and then the parallel mediation model, yield the same result in terms of how much of the relationship between the sexual orientation of women

and BMI are explained (R^2 value). Both modeling approach assess dietary intake and the second approach, the parallel mediation model, simply has the information by macronutrient group. When the models were tested without holding covariates constant, 1.05% of the relationship between the sexual orientation of women and BMI was explained by the potential mediators (total caloric intake and then intake of fat, carbohydrates, protein, and alcohol in parallel). When the models were tested with covariates held constant (age, smoking status, education level, and physical activity) 8.8% of the relationship between the sexual orientation of women and BMI was explained by the potential mediators (total caloric intake and then intake of fat, carbohydrates, protein, and alcohol in parallel).

4.4.2.2 Approach 1: Total Caloric Intake (mean Kcals)

From the mediation analysis with four covariates (age, education level, smoking status, and meeting government guidelines for moderate to vigorous physical activity) we found sexual orientation indirectly influences BMI through the association with total caloric intake. As can be seen in Figure 4-2 and Figure 4-3 and Table 4-2, SMW had higher caloric intake than heterosexual women (a=82.321 when covariates were not included and a= 86.336 when they were included), and that two women with the same sexual orientation but that differ by total caloric intake will differ by BMI (b=0.002) regardless of covariates in the model. The indirect effect of sexual orientation on BMI through total caloric intake is not zero by a 95% bias-corrected bootstrap confidence interval based on 10,000 bootstrap samples (without covariates in the model: 0.0374 to 0.4317, with a point estimate of 0.0973; with covariates in the model: 0.0276 to 0.3996, with a point estimate of 0.0938). When covariates are not in the model we see that sexual orientation's indirect relationship on BMI through total caloric intake includes the

path from sexual orientation to total caloric intake (a=82.321, p=0.0239) and the path from total caloric intake to BMI controlling for sexual orientation (b=0.002, p<0.001). When covariates were included in the model we saw that sexual orientation's indirect relationship on BMI through total caloric intake includes the path from sexual orientation to total caloric intake (a=86.336, p=0.0199) and the path from total caloric intake to BMI controlling for sexual orientation (b=0.002, p<0.001).

There was also evidence of a direct relationship, that is, sexual orientation leads to higher BMI independent of the effect of total caloric intake (c'=1.305, t(796)=2.910, p=0.004) in the absence of covariates and also when covariates were included (c'=1.602, t(793)=3.206, p=0.001). From the mediation model estimating total caloric intake, we show that caloric intake partially mediates the relationship between which sexual orientation exerts an effect on BMI when covariates were absent and when they were held constant.

When omitting covariates from the model, on average, SMW consume 82.321 more calories per day than heterosexual women (inference a). Two people with the same sexual orientation but differ by 1 calorie per day is estimated to differ by an increase of 0.002 BMI units (kg/m^2; inference b). SMW, compared to heterosexuals that have the same caloric intake, on average will have a difference in BMI of 1.305 kg/m^2 (direct effect tested Ho c'=0; Ha c'≠ 0). As a result of sexual orientation's influence on BMI through total caloric intake, SMW and heterosexual women differ by 0.181 kg/m^2 (indirect effects, ab pathway).

When covariates were included in the model, on average, SMW consume 86.336 more calories per day than heterosexual women (inference a). Two people with the same sexual orientation but differ by 1 calorie per day is estimated to differ by an increase of 0.002 BMI units (kg/m^2; inference b). SMW, compared to heterosexuals that have the same caloric intake, on average

will have a difference in BMI of 1.602 kg/m^2 (direct effect tested Ho c'=0; Ha c'≠ 0). As a result of sexual orientation's influence on BMI through total caloric intake, SMW and heterosexual women differ by 0.174 kg/m^2 (indirect effects, ab pathway).

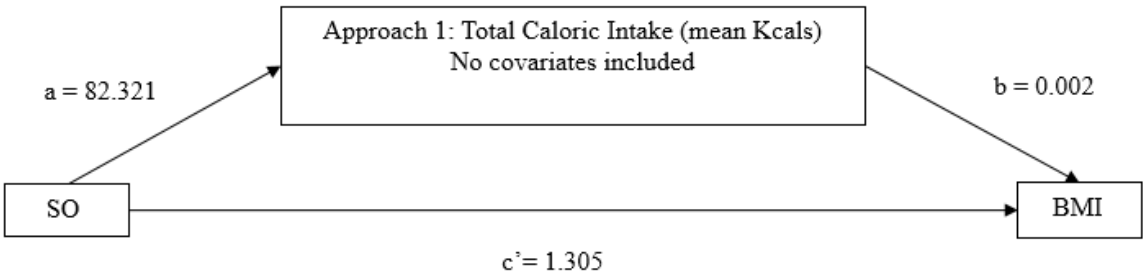

Figure 4-2. Simple Mediation Model for Total Caloric Intake, No Covariates Included

SO=sexual orientation; BMI= body mass index (kg/m^2)

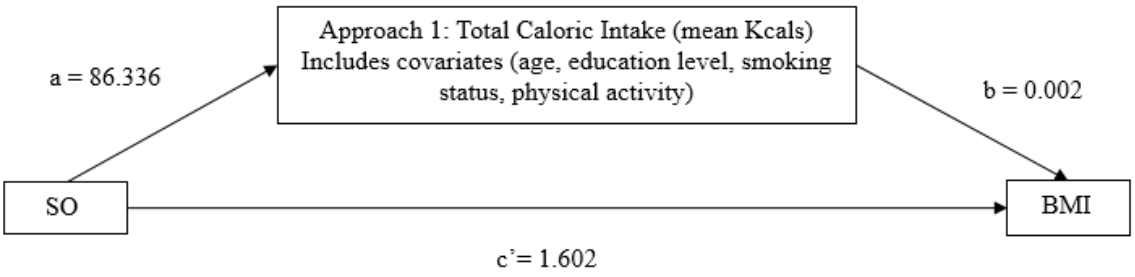

Figure 4-3. Simple Mediation Model for Total Caloric Intake, Covariates Included

SO=sexual orientation; BMI= body mass index (kg/m^2)

Table 4-2. Model Coefficients for Total Caloric Intake

Path	Regression Coefficient	Standard Error[1]	P Value	95% Confidence Interval
No Covariates Included				
Sexual Orientation to Total Caloric Intake (a)	82.321	36.365	0.024	10.938 to 153.703
Total Caloric Intake to BMI (b)	0.002	0.001	<0.001	0.001 to 0.003
Indirect Path from Sexual Orientation through Total Caloric Intake to BMI (ab)	0.181	0.097	n/a[2]	0.037 to 0.0432
Direct Path from Sexual Orientation to BMI (c')	1.305	0.506	0.010	0.311 to 2.298
Covariates Included (age, education level, smoking status, physical activity)				
Sexual Orientation to Total Caloric Intake (a)	86.336	37.000	<0.001	2,040.642 to 2,600.816
Total Caloric Intake to BMI (b)	0.002	0.001	<0.001	0.001 to 0.003
Indirect Path from Sexual Orientation through Total Caloric Intake to BMI (ab)	0.174	0.094	n/a[2]	0.028 to 0.400
Direct Path from Sexual Orientation to BMI (c')	1.602	0.500	0.001	0.621 to 2.583

[1] Standard errors for the regression coefficients are presented and for the indirect paths the standard error presented is the bootstrapping standard error

[2] when using bias-corrected bootstrapping you only look to the confidence interval to note significance; when zero is not crossed in the interval the indirect path is significant

4.4.2.3 Approach 2: Parallel Mediators, Fat, Carbohydrates, Protein, Alcohol

From the mediation analysis with four covariates (age, education level, smoking status, and meeting government guidelines for moderate to vigorous physical activity) we found sexual orientation indirectly influences BMI through the association with fat intake and not through the intake of carbohydrates, protein, or alcohol. This was found when covariates were not included and when they were included in the model. As can be seen in Figures 4-4 and 4-5 and Table 4-3, SMW had higher intake of fat, carbohydrate, protein, and alcohol than heterosexual women (respectively, a_1 =4.73g; a_2=5.53g; a_3=2.11g; a_4=1.67g when covariates were not included and a_1 =4.68g; a_2=7.59g; a_3=2.12g; a_4=1.11g when covariates were included); BMI varied by sexual

orientation and by macronutrient ($b_{1\text{-}4}$ in Figures 4-4 and 4-5). The indirect effect of sexual orientation on BMI through the potential mediators is significant when the bias-corrected bootstrap confidence interval does not include zero. The only macronutrient found to partially mediate sexual orientation on BMI was through fat intake (indirect effect confidence interval 0.046 to 0.505 with a point estimate of 0.114 when covariates were not included and 0.026 to 0.413 with a point estimate of 0.095 when covariates were included). The mediation model included four potential mediators being tested at the same time, each with an indirect path. Sexual orientation's indirect relationship on BMI through fat intake includes the path from sexual orientation to fat intake (a_1=4.729, p=0.026; a_1=4.675, p=0.031 covariates not included and included, respectively) and the path from fat intake to BMI controlling for sexual orientation (b_1=0.049, p<0.001; b_1=0.037, p<0.001 covariates not included and included, respectively). Sexual orientation's indirect relationship on BMI through carbohydrate intake includes the path from sexual orientation to carbohydrate intake (a_2=5.533, p=0.269; a_2=7.591, p=0.136 covariates not included and included, respectively) and the path from carbohydrate intake to BMI controlling for sexual orientation (b_2=-0.001, p=0.857; b_2=-0.002, p=0.690 covariates not included and included, respectively). Sexual orientation's indirect relationship on BMI through protein intake includes the path from sexual orientation to protein intake (a_3=2.114, p=0.188; a_3=2.124, p=0.195 covariates not included and included, respectively) and the path from protein intake to BMI controlling for sexual orientation (b_3=-0.004, p=0.769; b_3=0.010, p=0.446 covariates not included and included, respectively). Sexual orientation's indirect relationship on BMI through alcohol intake includes the path from sexual orientation to alcohol intake (a_4=1.672, p=0.026; a_4=1.106, p=0.146) and the path from alcohol intake to BMI controlling for

sexual orientation (b_4=-0.033, p=0.170; b_4=-0.017, p=0.446 covariates not included and included, respectively).

There was evidence of a direct relationship of sexual orientation leading to higher BMI independent of the relationships with the macronutrient groups when covariates were not included (c'=1.323, t(793)=2.619, p=0.009) and when they were included (c'=1.610, t(789)=3.228, p=0.001).

From the mediation model estimating components of dietary intake, we show that fat intake partially mediates the relationship between the sexual orientation of women and BMI without and with covariates in the model. From the model without covariates we found SMW consume 4.729 more grams of fat per day than heterosexual women (inference a). From the model with covariates held constant we found SMW consume 4.675 more grams of fat per day than heterosexual women (inference a). Two people with the same sexual orientation but differ by 1 grams of fat per day are estimated to differ by an increase of 0.049 BMI units (kg/m^2; inference b) when covariates are not in the model and by 0.037 BMI units (kg/m^2; inference b) when covariates are in the model. SMW, compared to heterosexuals that have the same dietary intake, on average will have a difference in BMI of 1.323 kg/m^2 when covariates are not in the model (direct effect tested Ho c'=0; Ha c'$\neq$ 0). SMW, compared to heterosexuals that have the same dietary intake, on average will have a difference in BMI of 1.610 kg/m^2 when covariates are in the model (direct effect tested Ho c'=0; Ha c'$\neq$ 0). As a result of sexual orientation's influence on BMI through fat intake, SMW and heterosexual women differ by 0.231 kg/m^2 when covariates are not in the model (indirect effects, ab pathway). As a result of sexual orientation's influence on BMI through fat intake, SMW and heterosexual women differ by 0.175 kg/m^2 when covariates are in the model (indirect effects, ab pathway).

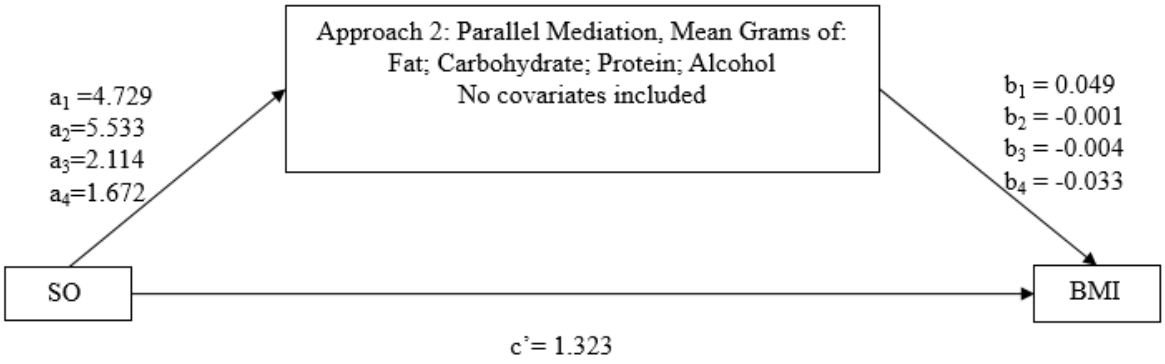

Figure 4-4. Parallel Mediation Model for Grams of Fat, Carbohydrate, Protein, and Alcohol, No Covariates Included

Where 1-4 are grams from fat, carbohydrate, protein, and alcohol, respectively. SO=sexual orientation; BMI= body mass index (kg/m^2)

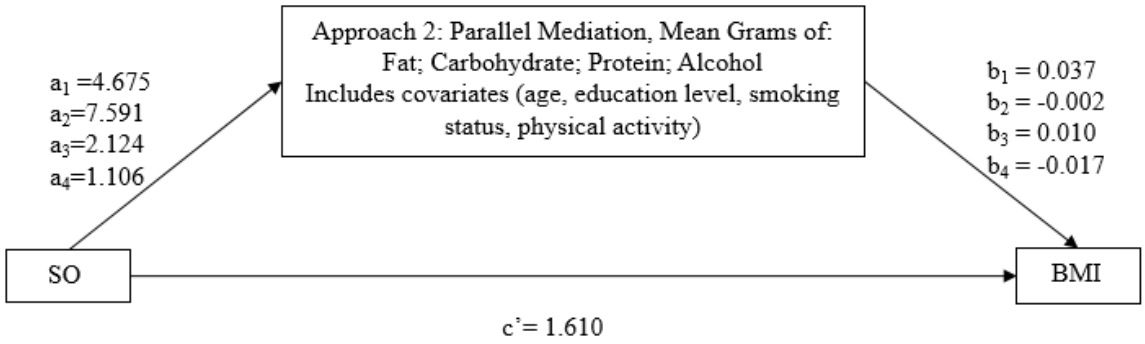

Figure 4-5. Parallel Mediation Model for Grams of Fat, Carbohydrate, Protein, and Alcohol, Covariates Included

Where 1-4 are grams from fat, carbohydrate, protein, and alcohol, respectively. SO=sexual orientation; BMI= body mass index (kg/m^2)

Table 4-3. Regression Coefficients, Standard Errors, and Model Summary Information for Multiple Mediators

Potential Mediator and Path	Regression Coefficient	Standard Error[1]	P Value	95% Confidence Interval
No Covariates Included				
Fat (g)				
Sexual Orientation to Fat Contribution (a_1)	4.729	2.121	0.026	0.567 to 8.891
Fat Contribution to BMI (b_1)	0.049	0.011	<0.001	0.028 to 0.070
Indirect Path from Sexual Orientation through Fat Contribution to BMI (ab_1)	0.231	0.114	n/a[2]	0.046 to 0.505
Carbohydrates (g)				
Sexual Orientation to Carbohydrate Contribution (a_2)	5.533	5.000	0.269	-4.281 to 15.348
Carbohydrate Contribution to BMI (b_2)	-0.001	0.004	0.857	-0.008 to 0.007
Indirect Path from Sexual Orientation through Carbohydrate Contribution to BMI (ab_2)	-0.004	0.029	n/a[2]	-0.087 to 0.039
Protein (g)				
Sexual Orientation to Protein Contribution (a_3)	2.114	1.604	0.188	-1.035 to 5.262
Protein Contribution to BMI (b_3)	-0.004	0.014	0.769	-0.031 to 0.023
Indirect Path from Sexual Orientation through Protein Contribution to BMI (ab_3)	-0.009	0.075	n/a[2]	-0.131 to 0.048
Alcohol (g)				
Sexual Orientation to Alcohol Contribution (a_4)	1.672	0.749	0.026	0.203 to 3.142
Alcohol Contribution to BMI (b_4)	-0.033	0.024	0.170	-0.080 to 0.014

Table 4-3. Continued

Indirect Path from Sexual Orientation through Alcohol Contribution to BMI (ab_4)	-0.055	0.075	n/a[2]	-0.211 to 0.096
Direct Path from Sexual Orientation to BMI (c')	1.323	0.505	0.009	0.331 to 2.314
Covariates Included (age, education level, smoking status, physical activity)				
Fat (g)				
Sexual Orientation to Fat Contribution (a_1)	4.675	2.160	0.031	0.435 to 8.916
Fat Contribution to BMI (b_1)	0.037	0.011	<0.001	0.017 to 0.058
Indirect Path from Sexual Orientation through Fat Contribution to BMI (ab_1)	0.175	0.095	n/a[2]	0.026 to 0.413
Carbohydrates (g)				
Sexual Orientation to Carbohydrate Contribution (a_2)	7.591	5.083	0.136	-2.387 to 17.569
Carbohydrate Contribution to BMI (b_2)	-0.002	0.004	0.690	-0.009 to 0.006
Indirect Path from Sexual Orientation through Carbohydrate Contribution to BMI (ab_2)	-0.012	0.035	n/a[2]	-0.0116 to 0.039
Protein (g)				
Sexual Orientation to Protein Contribution (a_3)	2.124	1.637	0.195	-1.090 to 5.337
Protein Contribution to BMI (b_3)	0.010	0.014	0.446	-0.016 to 0.037
Indirect Path from Sexual Orientation through Protein Contribution to BMI (ab_3)	0.022	0.043	n/a[2]	-0.025 to 0.177
Alcohol (g)				
Sexual Orientation to Alcohol Contribution (a_4)	1.106	0.761	0.146	-0.387 to 2.600
Alcohol Contribution to BMI (b_4)	-0.017	0.023	0.446	-0.063 to 0.029
Indirect Path from Sexual	-0.019	0.055	n/a[2]	-0.147 to 0.084

Table 4-3. Continued

Orientation through Alcohol Contribution to BMI (ab_4)				
Direct Path from Sexual Orientation to BMI (c')	1.610	0.499	0.001	0.631 to 2.588

[1] Standard errors for the regression coefficients are presented and for the indirect paths the standard error presented is the bootstrapping standard error

[2] when using bias-corrected bootstrapping you only look to the confidence interval to note significance; when zero is not crossed in the interval the indirect path is significant

4.5 DISCUSSION

The findings of a direct effect of sexual orientation on BMI and an indirect effect through total caloric intake are novel. Boehmer and Bowen [3] explored a mediation model that looked at dietary components as a mediator between the sexual orientation of women and BMI, which did not support the indirect effects of the dietary components as a mediator. There are several differences in Boehmer and Bowen's approach and our own. First, rather than using average daily servings of fruits/vegetables, our model utilized three-day food diary data that provided more specific information about dietary intake. Our model controlled for energy expenditure which allowed us to show that above and beyond any differences in physical activity between SMW and heterosexual women, total caloric intake and grams of fat were partial mediators of the relationship between the sexual orientation of women and BMI. Previous research did not find that energy expenditure mediates the relationship between the sexual orientation of women and BMI [3].

Boehmer and Bowen [3] used the Baron and Kenny [44] causal steps approach, whereas we used the Hayes approach [56,57]. The causal steps approach is considered one of the least powerful mediation tests [56], which is why we chose Hayes. Another mediation approach we considered was the product of coefficients approach; i.e., the Sobel test [58,59], which requires the assumption of normal distribution of the indirect effect sample. By using bootstrap CIs, we were able to repeatedly (e.g., 10,000 times) resample the distribution of the indirect effect through the software. This resulted in a percentile-based CIs, which in turn produced a bias-corrected CI

[56]. One limitation of bootstrapping is the sensitivity to distorted analysis if the sample is small or has large outliers, which did not occur in our sample.

Our research study has limitations. The dietary intake information from the ESTHER project is self-reported and collected over only three days. Generalizing a three-day food diary is a challenge, but reporting bias is reduced. The NDSR software was the 2007 version, so all food formulas are tied to that version of the software. While newer NDSR software exists, the food formulas may have changed, so it is not appropriate to update or re-run the data with newer software.

We included a broad measure of physical activity in the models to account for differences in energy expenditure. The ESTHER data did not show significant differences between sexual orientation groups by hours per week of physical activity, or by hours per week of moderate and vigorous physical activity. Group differences by sexual orientation have been investigated using the ESTHER data and no group differences were found for time spent for leisure physical activities (e.g. sports, outdoor activities, etc) or occupational physical activities were found [60].

Our research supports sexual orientation as a risk factor for obesity, but also supports caloric intake and dietary intake of fat as mediators of the relationship. In regards to the theories on why SMW have an association with obesity, our research did not include information about body image or CSA. Our research accounted for physical activity in the model, so the dietary mediating relationship exists despite any differences in measured physical activity. The impact of living in a minority environment, as outlined in the minority stress theory model, could yield associations with obesity. Our research demonstrates something beyond simply sexual orientation associated with higher BMI. Our research also shows that dietary intake plays a role in that relationship. As such, living in an environment of stigma, prejudice, and discrimination

itself are known stressors and eating behavior has been linked to stress [61,62] and thus could have an association with higher BMI. Other factors not included in our model could also be explored. Longitudinal research is needed to assess the causal relationship between factors in the minority stress model and obesity.

Broadly, the literature reports that SMW have a higher BMI than heterosexual women. There is evidence that statistically significant dietary differences are present between the sexual orientation groups in this sample [9]. The relationship between the sexual orientation of women and BMI is partially mediated by total caloric intake and mean grams of fat per day, as reported in this research paper. Generally, the literature reports that SMW have a higher alcohol intake than heterosexual women, and the same was true of this sample [9]. However, alcohol intake was not a significant mediator in the association of sexual orientation and BMI.

Obesity is a preventable risk factor for CVD, and SMW are at higher risk of being obese. Future research should explore other reasons for obesity in this population, perhaps drawing from the minority stress theory model and including mental health variables such as depression and anxiety status. Understanding mediating factors on sexual orientation and BMI, such as risk for depression or mental health outcomes, could better inform the relationship and suggest appropriate interventions.

4.6 ACKNOWLEDGEMENTS

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4.7 DISCLOSURE STATEMENT

No competing financial conflicts exist for any of the authors.

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5.0 SEXUAL ORIENTATION OF WOMEN AND BODY MASS INDEX BY LIFETIME HISTORY OF DEPRESSION: DOES CURRENT DEPRESSION MEDIATE?

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5.1 ABSTRACT

Background and Objective: Sexual minority women (SMW) have higher rates of being overweight and obese than heterosexual women. The minority stress theory model hypothesizes that mental health disparities between sexual minorities and heterosexuals are from a stressful environment created by stigma, prejudice, and discrimination. The aim of this research was to explore the relationship between the sexual orientation in women and BMI, specifically investigating the mediating effects of current depression when the sample was stratified by lifetime history of depression.

Methods: This secondary data analysis utilized data from the **E**pidemiologic **ST**udy of **HE**alth **R**isk in Women (ESTHER) Project (Pittsburgh, PA). The sample included 424 SMW and 365 heterosexual women age 35 to 64 years. The data were stratified by lifetime history of depression. Current depression, using a continuous Center for Epidemiologic Studies Depression Scale Revised (CESD-R) score, was tested as a potential mediator. The predictor was sexual orientation and the outcome continuous BMI; covariates were included in the model (age, education level, smoking status, mean daily caloric intake from a three-day food diary, meeting government guidelines for moderate to vigorous physical activity). The model was estimated using the PROCESS macro in SPSS (Hayes mediation approach).

Results: We found SMW had significantly higher rates of lifetime history of depression ($p<0.001$) and higher BMI ($p=0.002$) than heterosexual women. We did not find evidence that current depression mediates the relationship between the sexual orientation in women and BMI.

We found that women with no lifetime history of depression did not have a significant association between the sexual orientation of women and BMI ($p=0.225$).

Conclusion: This research examined BMI disparities between SMW and heterosexual women. Current depression was found not to play a role in the relationship. Evidence of a statically significant association between the sexual orientation of women and BMI was only present with women self-reported a lifetime history of depression.

5.2 INTRODUCTION

Obesity (body mass index [BMI] ≥30 kg/m^2) is a major public health concern. Obesity is a leading health indicator, with greater body size associated with increases in all-cause mortality. Obesity is associated with increased risk of hypertension, dyslipidemia, type 2 diabetes, coronary heart disease, stroke, gallbladder disease, osteoarthritis, respiratory problems, and certain cancers (including breast, endometrial, colon) [1]. A population at particularly high risk of obesity is sexual minority women (SMW) as obesity rates are higher among SMW than heterosexual women [2-10]. The Institute of Medicine's first report on the health of lesbian, gay, bisexual, and transgender people reported theories on why SMW may be more obese or overweight than heterosexual women. The theories include that obesity is associated with minority stress exposure; SMW do not conform to society's ideal thinness; differences in exercise patterns exist between SMW and heterosexual women; and childhood sexual abuse (CSA), a risk factor for multiple deleterious health outcomes, is more prevalent among SMW [11].

The minority stress theory model is widely accepted and attempts to explain the disparities in mental health between sexual minorities and heterosexuals. The minority stress theory model hypothesizes that the stressful environment created by stigma, prejudice, and discrimination against SMW, causes mental health issues, and this may explain the greater prevalence of mental health disorders among sexual orientation minorities [12,13]. The existing literature supports evidence that sexual minorities have higher rates of anxiety and depression compared with heterosexuals [13-17].

A meta-analysis of community-based studies found that in the general population there is a significant association between depression and obesity but among women the association is markedly higher than among men [18]. Major depression in women can lead to serious health risks, including metabolic syndrome [19] and obesity is closely linked with metabolic syndrome [20]. Exposure to stress can lead to increased eating behavior [21-23] which, if not balanced with enhanced physical activity, can lead to overweight or obesity.

Compared to heterosexuals, SMW are considered to be at higher risk for obesity and for mental health problems. Psychological distress, such as depression, can impact eating behaviors. Given this dynamic, SMW are a particularly vulnerable group for long-term health impacts. The aim of this research was to explore the relationship between the sexual orientation of women and BMI, specifically investigating current depression as a mediator when a sample of women are stratified by lifetime history of depression.

5.3 METHODS

5.3.1 Study Design and Sample

This secondary data analysis uses data from the **E**pidemiologic **ST**udy of **HE**alth **R**isk in Women (ESTHER) Project collected in Pittsburgh, PA. The ESTHER project was a cross-sectional observational study that collected data from 2003-2006 with the aim of studying risk factors for cardiovascular disease among adult women [10,24-26].

Women who were age 35 years and older, were not pregnant, and had no previous history of heart disease (angina, heart attack, or stroke) were eligible for the study. Sexual orientation was documented at recruitment (defined below in the Independent Variable section). The recruitment method involved convenience sampling and women were recruited via newspaper and radio advertisements, community health events, LGBT events/socials, and the University of Pittsburgh broadcast phone-message system.

All of the participants signed an informed consent form that was approved, along with the study protocol, by The University of Pittsburgh's Institutional Review Board (IRB). The women were reimbursed $50. Funding for the ESTHER Project was provided by the National Heart, Lung, and Blood Institute, R01HL067052.

The ESTHER study sample was reduced to 789 (heterosexual n=365; SMW n=424) for this analysis. Participants who were underweight or had caloric outliers (less than 500 or greater than 4,500 kilocalories per day) were excluded [27,28]. The data were highly skewed with a greater number of older heterosexual women compared with older SMW; therefore, only heterosexuals age less than 65 years were included. Also, heterosexual African-American women were randomly selected to stay in the sample, as there was a disproportionately low prevalence of African-American SMW.

The sample size was further reduced by excluding individuals who were missing key variables: BMI, self-report of past depression, current depression screening score (Center for Epidemiologic Studies Depression Scale Revised, CESD-R), age, three-day food diary data, and time spent per week on moderate and vigorous physical activity.

5.3.2 Dependent Variable

Continuous BMI was the dependent variable in the mediation models. Body weight was assessed in kilogram using a calibrated balance beam scale. Researchers measured standing height in feet and inches using a wall-mounted Harpendon stadiometer, then converted to meters for calculating BMI (kg/m^2).

5.3.3 Independent Variable

Sexual orientation was included as the independent variable in the moderated mediation model (heterosexual women coded 0; SMW coded as 1). Participants identifying as heterosexual or straight *and* only having male sexual partners since the age of 18 years were grouped as heterosexual women. SMW were women who identified as lesbian or bisexual *and* having emotional, physical, and romantic attractions within the past five years toward only or primarily women, or whose relationships within the past five years had been with only or primarily women [25].

5.3.4 Covariates

The covariates included in the model were age, highest education level completed, smoking status, energy intake, and energy expenditure.

Age was a continuous variable recorded in years. Highest education level completed and smoking status were categorical as shown in Table 1. Smoking status was included because smoking has been associated with both lower BMI (appetite reduction) and increase BMI (heavy

smoking), as well as having impacts on the metabolic syndrome [34]. The variable for energy intake was the mean daily caloric intake from the sample's three-day food diary data. A comparison of the dietary intake by sexual orientation and methods describing the data collection and analysis is presented elsewhere [10]. Briefly, women recorded their food intake for three days: two weekdays and one weekend day. Dietary data were entered into, and analyzed by, the Nutrition Data System for Research (NDSR) software version 2007, developed by the Nutrition Coordinating Center (NCC), University of Minnesota, Minneapolis, MN. The NDSR provides a complete nutrient profile for all foods in the database [29-31]. The covariate for energy expenditure was whether the participant met national guidelines for moderate and vigorous physical activity (dichotomous yes/no variable). Women met the guideline if they self-reported weekly participation in at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic physical activity. Combinations of moderate and vigorous physical activity were combined using the guidelines' recommendation of 1 minute of vigorous activity is equal to 2 minutes of moderate physical activity. Previous research among SMW used the same approach to combine moderate and vigorous physical activity, and assess if government guidelines were met [10,32,33]. Race was not included as a covariate because the sample was already adjusted due to the disproportionately low prevalence of African-American SMW.

5.3.5 Mediator

The continuous score from the Center for Epidemiologic Studies Depression Scale Revised (CESD-R) was evaluated as a potential mediator in the model. Originally created in 1977, the CESD was revised in 2004 and is often used in psychiatric epidemiology research and also national studies such as the National Health and Nutrition Examination Survey [39-45]. The

questionnaire is a 20-item, self-report instrument, that evaluates frequency of feelings and behavior in the past two weeks to assess current symptoms of depression. The CESD-R has nine domains that follow depression diagnosis guidelines as defined by the American Psychiatric Association Diagnostic and Statistical Manual, fifth edition [46]. The domains are: sadness (dysphoria); loss of interest (anhedonia); appetite changes; sleep; thinking/concentration difficulties; guilt (worthlessness); tired (fatigued); movement (agitation); and suicidal ideation. A total score can be generated by adding the responses to each item (not at all or less than 1 day=0; 1-2 days=1; 3-4 days=2; 5-7 days=3; nearly every day for 2 weeks=3). Responders are categorized as screening negative for depression if their total score is less than 16 [47].

5.3.6 Analytic Approach

The sample was stratified to two groups based on self-reported lifetime history of depression (no/yes). For each of the stratified groups a mediation model was tested. We used an ordinary least squares path analysis to explore the possible mediating effects of current depression (Figure 5-1). The Hayes modeling approach using the PROCESS macro (versions 2.12.1 and 2.15), model number 4, was utilized [48]. Indirect effects were evaluated using a bias-corrected confidence interval. The random resampling of the data, bootstrapping, was conducted 10,000 times. All statistical analyses were performed using SPSS (IBM SPSS Statistics versions 20 and 23).

The modeling approach we used was an integrated conditional process rather than a stepwise approach that may be more traditional (e.g. Baron and Kenny [49]). By using the integrated approach the focus turns from individual pathways to the process as a whole [48,50]. The

analysis estimates the statistical relationship sexual orientation has on BMI (direct effects). The analysis estimates how sexual orientation influences BMI through current depression, the potential mediator. The normal theory test for indirect effects (e.g. Sobel test [51,52]) is traditionally used but can be sensitive to sampling distribution, has low power, and generates confidence intervals that are arguably less accurate than other approaches [48]. Software packages have computing power to randomly select and statically 'resample' the data any number of times (we used 10,000 times) to produce a confidence interval for the indirect effects. More information about the differences in the causal steps approach and Hayes mediation can be found in, "*Beyond Baron and Kenny: statistical mediation analysis in the new millennium*" [50].

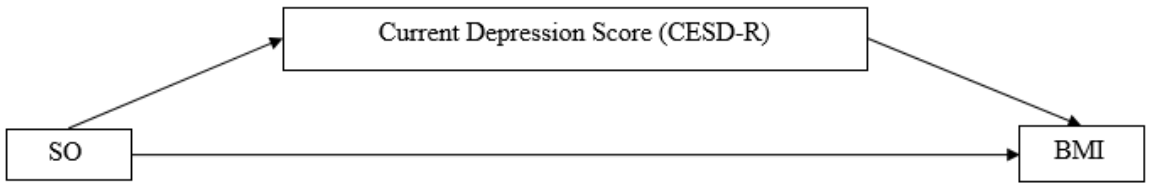

Figure 5-1. Estimated Mediation Model

SO=sexual orientation; BMI= body mass index (kg/m^2); the same model was used for women with no lifetime history of depression and with women who reported a lifetime history of depression

5.4 RESULTS

5.4.1 Participant Characteristics

Participant characteristics are presented in Table 5-1. Just over half the sample identified as being a SMW (53.7%). The sample was primarily Caucasian (92.6%) and not Hispanic (99.4%), highly educated (66.3% completing a bachelor's degree or higher), and reported having a mean household income of at least $60,000 (46.1%). Only 35.4% of the total sample was within the normal range for BMI.

When comparing SMW to heterosexual women, there were statistically significant mean group differences. Heterosexual women had a higher rate of parity than SMW for the combine sample (69.3% vs. 26.2%, $p<0.001$) and the statistically significant group differences remained for both cohorts of lifetime history of depression status ($p<0.001$ for both no lifetime history of depression and lifetime history of depression). Significant group differences were found between SMW and heterosexual women for the combine sample, no lifetime history of depression and lifetime history of depression ($p<0.001$; $p<0.001$; $p=0.011$, respectively).

Education level was significantly different between SMW and heterosexual women for the combine sample and for women with no lifetime history of depression but not by sexual orientation in women who had a lifetime history of depression. The same pattern was true for number of alcoholic drinks per month: significantly different by sexual orientation in women for the combine sample and for women with no lifetime history of depression but not by sexual orientation in women who had a lifetime history of depression.

For the women with no lifetime history of depression, there were no differences in continuous BMI or categorical BMI by sexual orientation groups. Statistically significant group differences by sexual orientation groups in women were found for the combine sample and the cohort with a lifetime history of depression.

Table 5-1. Participant Characteristics

Variable	Total Sample (N=789)	Combine Sample			No Lifetime History of Depression			Lifetime History of Depression		
		Heterosexual Women (n=365) n (%)	Sexual Minority Women (n=424) n (%)	Value P	Heterosexual Women (n=244) n (%)	Sexual Minority Women (n=231) n (%)	Value P	Heterosexual Women (n=121) n (%)	Sexual Minority Women (n=193) n (%)	Value P
Age, Years										
Mean (SD)	47.59 (7.33)	47.75 (7.61)	47.45 (7.09)	0.567	47.21 (7.52)	47.23 (7.23)	0.976	48.83 (7.70)	47.71 (6.94)	0.181
Range	35-64	35-64	35-64		35-63	35-64		35-64	35-63	
Age Categories										
35-39	113 (14.3%)	55 (15.1%)	58 (13.7%)		38 (15.6%)	35 (15.2%)		17 (14.0%)	23 (11.9%)	
40-44	183 (23.2%)	83 (22.7%)	100 (23.6%)		63 (25.8%)	52 (22.5%)		20 (16.5%)	48 (24.9%)	
45-49	194 (24.6%)	85 (23.3%)	109 (25.7%)	0.636	60 (24.6%)	70 (30.3%)	0.885	25 (20.7%)	39 (20.2%)	0.310
50-54	139 (17.6%)	59 (16.2%)	80 (18.9%)		29 (11.9%)	32 (13.9%)		30 (24.8%)	48 (24.9%)	
55-64	160 (20.3%)	83 (22.7%)	77 (18.2%)		54 (22.1%)	42 (18.2%)		29 (24.0%)	35 (18.1%)	

Table 5-1. Continued

Variable	Total Sample (N=789)	Combine Sample			No Lifetime History of Depression			Lifetime History of Depression		
		Heterosexual Women (n=365) n (%)	Sexual Minority Women (n=424) n (%)	Value P	Heterosexual Women (n=244) n (%)	Sexual Minority Women (n=231) n (%)	Value P	Heterosexual Women (n=121) n (%)	Sexual Minority Women (n=193) n (%)	Value P
Parity										
Nulliparous	425 (53.9%)	112 (30.7%)	313 (73.8%)	<0.001	71 (29.1%)	175 (75.8%)	<0.001	41 (33.9%)	138 (71.5%)	<0.001
Parous	364 (46.1%)	253 (69.3%)	111 (26.2%)		173 (70.9%)	56 (24.2%)		80 (66.1%)	55 (28.5%)	
Race										
Caucasian	731 (92.6%)	336 (92.1%)	395 (93.2%)	0.554	223 (91.4%)	220 (95.2%)	0.093	113 (93.4%)	175 (90.7%)	0.397
African-American	58 (7.4%)	29 (7.9%)	29 (6.8%)		21 (8.6%)	11 (4.8%)		8 (6.6%)	18 (9.3%)	
Ethnicity										
Not Hispanic or Latino	784 (99.4%)	363 (99.5%)	421 (99.3%)	0.779	242 (99.2%)	228 (98.7%)	0.610	121 (100%)	193 (100%)	-
Hispanic or Latino	5 (0.6%)	2 (0.5%)	3 (0.7%)		2 (0.8%)	3 (1.3%)		0	0	
BMI kg/m^2										
Mean (SD)	28.9 (7.18)	28.06 (6.31)	29.62 (7.79)	0.002	27.75 (6.02)	28.26 (7.10)	0.403	28.68 (6.84)	31.26 (8.28)	0.004
Range	18.55-70.09	18.61-52.66	18.55-70.09		18.92-52.66	18.55-70.09		18.61-52.53	18.55-65.44	

Table 5-1. Continued

Variable	Total Sample (N=789)	Combine Sample			No Lifetime History of Depression			Lifetime History of Depression		
		Heterosexual Women (n=365) n (%)	Sexual Minority Women (n=424) n (%)	Value P	Heterosexual Women (n=244) n (%)	Sexual Minority Women (n=231) n (%)	Value P	Heterosexual Women (n=121) n (%)	Sexual Minority Women (n=193) n (%)	Value P
BMI Categories¥										
Normal	279 (35.4%)	138 (37.8%)	141 (33.3%)		98 (40.2)	88 (38.1%)		40 (33.1%)	53 (27.5%)	
Overweight	230 (29.2%)	120 (32.9%)	110 (25.9%)		77 (31.6%)	66 (28.6%)		43 (35.5%)	44 (22.8%)	
Obese-Class I	139 (17.6%)	53 (14.5%)	86 (20.3%)	0.003	37 (15.2%)	47 (20.3%)	0.381	16 (13.2%)	39 (20.2%)	0.007
Obese-Class II	80 (10.1%)	34 (9.3%)	46 (10.8%)		21 (8.6%)	14 (6.1%)		13 (10.7%)	32 (16.6%)	
Obese-Class III	61 (7.7%)	20 (5.5%)	41 (9.7%)		11 (4.5%)	16 (6.9%)		9 (7.4%)	25 (13.0%)	
Calories per day										
Mean (SD)	1,861.76 (512.55)	1,817.27 (507)	1,900.05 (514.81)	0.024	1,794.79 (492.24)	1,850.23 (479.51)	0.215	1,862.63 (534.69)	1,959.67 (549.46)	0.125
Range	529.75-3,667.35	529.8-3,463.0	699.9-3,667.35		601.34-3,463.08	699.94-3,369.17		529.75-3,268.76	763.62-3,667.35	
Total Physical Activity, Hours per Week	9.30 (11.9)	8.71 (11.42)	9.81 (12.25)	0.197	9.88 (12.46)	10.53 (12.79)	0.577	6.35 (8.54)	8.94 (11.54)	0.023

Table 5-1. Continued

Variable	Total Sample (N=789)	Combine Sample			No Lifetime History of Depression			Lifetime History of Depression		
		Heterosexual Women (n=365) n (%)	Sexual Minority Women (n=424) n (%)	Value P	Heterosexual Women (n=244) n (%)	Sexual Minority Women (n=231) n (%)	Value P	Heterosexual Women (n=121) n (%)	Sexual Minority Women (n=193) n (%)	Value P
Government Guidelines for Mod/Vig PA, Yes n (%)	595 (75.4%)	278 (76.2%)	317 (74.8%)	0.649	187 (76.6%)	185 (80.1%)	0.363	91 (75.2%)	132 (68.4%)	0.189
Education										
< 12 years	4 (0.5%)	2 (0.5%)	2 (0.5%)		1 (0.4%)	1 (0.4%)		1 (0.8%)	1 (0.5%)	
High School or GED	77 (9.8%)	49 (13.4%)	28 (6.6%)		40 (16.4%)	13 (5.6%)		9 (7.4%)	15 (7.8%)	
Some College	185 (23.4%)	87 (23.8%)	98 (23.1%)	0.003	53 (21.7%)	47 (20.3%)	0.001	34 (28.1%)	51 (26.4%)	0.590
Bachelors	202 (25.6%)	94 (25.8%)	108 (25.5%)		63 (25.8%)	64 (27.7%)		31 (25.6%)	44 (22.8%)	
Graduate+	321 (40.7%)	133 (36.4%)	188 (44.3%)		87 (35.7%)	106 (45.9%)		46 (38.0%)	82 (42.5%)	
Household Income										
Less than $15,000	59 (7.5%)	29 (7.9%)	30 (7.1%)	0.291	11 (4.5%)	7 (3.0%)	0.183	18 (14.9%)	23 (11.9%)	0.261

Table 5-1. Continued

Variable	Total Sample (N=789)	Combine Sample			No Lifetime History of Depression			Lifetime History of Depression		
		Heterosexual Women (n=365) n (%)	Sexual Minority Women (n=424) n (%)	Value P	Heterosexual Women (n=244) n (%)	Sexual Minority Women (n=231) n (%)	Value P	Heterosexual Women (n=121) n (%)	Sexual Minority Women (n=193) n (%)	Value P
$15,000-$24,999	49 (6.2%)	25 (6.8%)	24 (5.7%)		16 (6.6%)	8 (3.5%)		9 (7.4%)	16 (8.3%)	
$25,000-$39,999	130 (16.5%)	63 (17.3%)	67 (15.8%)		33 (13.5%)	35 (15.2%)		30 (24.8%)	32 (16.6%)	
$40,000-$59,999	172 (21.8%)	79 (21.6%)	93 (21.9%)		58 (23.8%)	54 (23.4%)		21 (17.4%)	39 (20.2%)	
$60,000-$74,999	101 (12.8%)	36 (9.9%)	65 (15.3%)		26 (10.7%)	34 (14.7%)		10 (8.3%)	31 (16.1%)	
$75,000 or more	263 (33.3%)	121 (33.2%)	142 (33.5%)		89 (36.5%)	92 (39.8%)		32 (26.4%)	50 (25.9%)	
Missing	15 (1.9%)	12 (3.3%)	3 (0.7%)		11 (4.5%)	1 (0.4%)		1 (0.8%)	2 (1.0%)	
Medical Insurance										
Yes	724 (91.8%)	335 (91.8%)	389 (91.7%)	0.971	230 (94.3%)	217 (93.9%)	0.739	105 (86.8%)	172 (89.1%)	0.450
No	63 (8.0%)	29 (7.9%)	34 (8.0%)		13 (5.3%)	14 (6.1%)		16 (13.2%)	20 (10.4%)	
Missing	2 (0.3%)	1 (0.3%)	1 (0.2%)		1 (0.4%)	0		0	1 (0.5%)	
Menopause Status*				0.113			0.284			0.224

Table 5-1. Continued

Variable	Total Sample (N=789)	Combine Sample			No Lifetime History of Depression			Lifetime History of Depression		
		Heterosexual Women (n=365) n (%)	Sexual Minority Women (n=424) n (%)	Value P	Heterosexual Women (n=244) n (%)	Sexual Minority Women (n=231) n (%)	Value P	Heterosexual Women (n=121) n (%)	Sexual Minority Women (n=193) n (%)	Value P
Menopause Not Suspected	629 (79.7%)	282 (77.3%)	347 (81.8%)		190 (77.9%)	189 (81.8%)		41 (33.9%)	138 (71.5%)	
Menopause	160 (20.3%)	83 (22.7%)	77 (18.2%)		54 (22.1%)	42 (18.2%)		80 (66.1%)	55 (28.5%)	
Smoking Status										
Never	408 (51.7%)	219 (60.0%)	189 (44.6%)		150 (61.5%)	109 (47.2%)		69 (57.0%)	80 (41.5%)	
Former	295 (37.4%)	120 (32.9%)	175 (41.3%)	<0.001	81 (33.2%)	93 (40.3%)	<0.001	39 (32.2%)	82 (42.5%)	0.011
Current	86 (10.9%)	26 (7.1%)	60 (14.2%)		13 (5.3%)	29 (12.6%)		13 (10.7%)	31 (16.1%)	
Number of Alcoholic Drinks per Month										
Mean (SD)	8.23 (16.22)	6.93 (13.03)	9.32 (18.43)		7.05 (13.16)	10.28 (14.74)		6.69 (12.83)	8.18 (22.03)	
Range	0-216.67	0-91.00	0-216.67	0.036	0-91.00	0-75.83	0.013	0-86.67	0-216.67	0.508
Missing	21 (2.7%)	13 (3.6%)	8 (1.9%)		8 (3.3%)	5 (2.2%)		5 (4.1%)	3 (1.6%)	
Self-report History of	314 (39.8%)	121 (33.2%)	193 (45.5%)	<0.001	-	-	-	121 (100%)	193 (100%)	-

Table 5-1. Continued

Variable	Total Sample (N=789)	Combine Sample			No Lifetime History of Depression			Lifetime History of Depression		
		Heterosexual Women (n=365) n (%)	Sexual Minority Women (n=424) n (%)	Value P	Heterosexual Women (n=244) n (%)	Sexual Minority Women (n=231) n (%)	Value P	Heterosexual Women (n=121) n (%)	Sexual Minority Women (n=193) n (%)	Value P
Depression										
Self-report History of Anxiety	202 (25.6%)	82 (22.5%)	120 (28.3%)	0.060	21 (9.4%)	21 (9.1%)	0.853	61 (50.4%)	99 (51.3%)	0.901
Missing	2 (0.3%)	1 (0.3%)	1 (0.2%)		0	0		1 (0.8%)	1 (0.5%)	
CESD-R Score										
Mean (SD)	6.09 (4.89)	5.82 (4.60)	6.31 (5.12)	0.159	4.77 (3.65)	4.74 (4.08)	0.932	7.95 (5.50)	8.20 (5.58)	0.696
Range	0-23	0-23	0-23		0-17	0-22		0-23	0-23	

¥ Normal weight (BMI = 18.5-24.9); overweight (BMI = 25.0-29.9); obese-class I (BMI = 30.00-34.99); obese-class II (BMI = 35.00-39.99); obese-class III (BMI ≥40.00).

* Based on age alone (55 years).

5.4.2 Stratification

The data were stratified by self-reported lifetime history of depression: women who did not have a lifetime history of depression and women who did report a lifetime history of depression. Table 5-2 displays the sample size and CESD-R score information by stratification cohort. There were no group differences for CESD-R scores by sexual orientation for the whole sample, the women who did not have a lifetime history of depression, or women who did have a lifetime history of depression (p=0.159, p=0.932, p=0.696 respectively).

Table 5-2. CESD-R Score by Stratified Cohort

Stratification Group	Total Sample	Heterosexual Women	Sexual Minority Women	Value P
No stratification, Total Sample	N=789	n=365	n=424	
Mean (SD)	6.09 (4.89)	5.82 (4.60)	6.31 (5.12)	0.159
Range	0-23	0-23	0-23	
No Lifetime History of Depression	N=475	n=244	n=231	
Mean (SD)	6.09 (4.89)	4.77 (3.65)	4.74 (4.08)	0.932
Range	0-22	0-17	0-22	
Lifetime History of Depression	N=314	n=121	n=193	
Mean (SD)	8.11 (5.54)	7.95 (5.50)	8.20 (5.58)	0.696
Range	0-23	0-23	0-23	

5.4.3 Mediating Models

5.4.3.1 Combine Sample of Lifetime History of Depression

The mediation models were estimated with the total sample, women who did not have a lifetime history of depression, and women who did report a lifetime history of depression. Five covariates (age, education level, smoking status, mean daily caloric intake, meeting government guidelines for moderate to vigorous physical activity) were held constant. Figure 5-2 displays the regression coefficients for the modeling pathways and detailed model results are presented in Table 5-3.

5.4.3.2 No Stratification, Total Sample

When the total sample of ESTHER women were included in the mediation model we discovered that the statistical relationship between sexual orientation and BMI was significant (direct effects, c'=1.562, t(781)=0.496, p=0.002). We found the indirect effects were not statistically significant (CI crossed zero: -0.040 to 0.230), indicating that current depression does not mediate the relationship between the sexual orientation of women and BMI.

5.4.3.3 No Lifetime History of Depression

When only considering the ESTHER women who did not have a lifetime history of depression we found there was no evidence of a statistical relationship between the sexual orientation of women and BMI (no direct effects; c'=0.736, t(467)=1.214, p=0.225). We did not find evidence that current depression mediated a relationship between the sexual orientation of women and BMI; there was no evidence of indirect effects (CI crossed zero: -0.098 to 0.038).

5.4.3.4 Lifetime History of Depression

For the ESTHER women who did self-report a history of depression within their lifetime, we found that the statistical relationship between the sexual orientation of women and BMI was significant (direct effects, c'=2.274, t(307)=0.851, p=0.008). We found the indirect effects were not statistically significant (CI crossed zero: -0.206 to 0.366), indicating that current depression does not mediate the relationship between the sexual orientation of women and BMI.

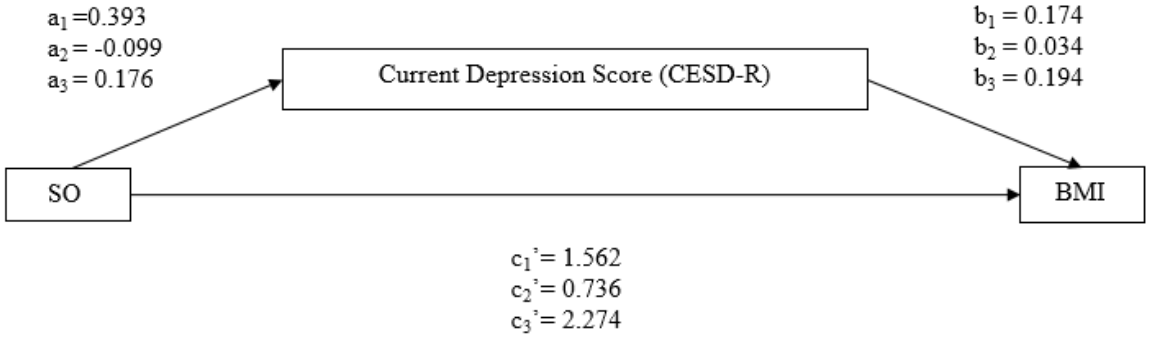

Figure 5-2. Mediation Model with Regression Coefficients

Where 1-3 are the total sample, the segment of the sample with no lifetime history of depression, and the segment of the sample with a lifetime history of depression. SO=sexual orientation; BMI= body mass index (kg/m^2)

Table 5-3. Regression Coefficients, Standard Errors, and Model Summary Information

Path	Regression Coefficient	Standard Error[1]	P Value	95% Confidence Interval
Combine Sample				
Sexual orientation to current depression (a_1)	0.0393	0.351	0.263	-0.296 to 1.081
Current depression to BMI (b_1)	0.174	0.051	p<0.001	0.075 to 0.273
Indirect Path from Sexual Orientation through current depression to BMI (ab_1)	0.068	0.067	n/a[2]	-0.040 to 0.230
Direct Path from Sexual Orientation to BMI (c_1')	1.562	0.496	0.002	0.588 to 2.536
No Lifetime History of Depression				
Sexual orientation to current depression (a_2)	-0.099	0.364	0.786	-0.814 to 0.616
Current depression to BMI (b_2)	0.034	0.077	0.663	-0.118 to 0.185
Indirect Path from Sexual Orientation through current depression to BMI (ab_2)	-0.003	0.029	n/a[2]	-0.098 to 0.038
Direct Path from Sexual Orientation to BMI (c_2')	0.736	0.606	0.225	-0.455 to 1.927
Lifetime History of Depression				
Sexual orientation to current depression (a_3)	0.176	0.633	0.781	-1.070 to 1.422
Current depression to BMI (b_3)	0.194	0.077	0.012	0.044 to 0.345
Indirect Path from Sexual Orientation through current depression to BMI (ab_3)	0.034	0.138	n/a[2]	-0.206 to 0.366
Direct Path from Sexual Orientation to BMI (c_3')	2.274	0.851	0.008	0.600 to 3.947

[1] Standard errors for the regression coefficients are presented and for the indirect paths the standard error presented is the bootstrapping standard error

[2] when using bias-corrected bootstrapping you only look to the confidence interval to note significance; when zero is not crossed in the interval the indirect path is significant

5.5 DISCUSSION

Our approach is novel and to our knowledge no other studies have investigated the mediating effects of current depression in the association of sexual orientation in women and BMI by lifetime history of depression. We found no evidence of a direct relationship between the sexual orientation of women and BMI for the ESTHER women who had no lifetime history of depression. The same is not true for the ESTHER women who did have a lifetime history of depression. We found that the direct path from sexual orientation to BMI was significant for women who reported a lifetime history of depression. This difference by lifetime history of depression suggests sexual orientation's relationship with BMI is contingent upon depression history and that it may actually be the lifetime history of depression driving differences in BMI in women and not sexual orientation alone. Current depression, using the CESD-R score, did not explain the relationship between the sexual orientation of women and BMI in our research. The combine sample that includes women with, and without, a lifetime history of depression maintains the significant relationship between the sexual orientation of women and BMI. This indicates that lifetime history of depression may play a critical role in uncovering disparities in BMI of women.

We considered the existing literature that reports SMW have higher BMI than heterosexual women [2-10], that sexual minorities endure a lifetime of psychological distress [12,13] and have higher rates of anxiety and depression [13-17] when we designed this secondary analysis research. We reflected the importance of lifetime history of depression in the modeling approach.

The ESTHER data showed that SMW reported significantly more lifetime history of depression than heterosexual women (<0.001) and lifetime history of anxiety approached significance (p=0.060) for SMW above heterosexual women. Despite the historical psychological impact, the sample did not have significant group mean differences between SMW and heterosexual women's CESD-R scores. A potential reason could be that the SMW were informed of their health risks and had the means to address the psychological risks. The SMW in the sample were highly educated and have a fairly high household income (48.8% of SMW households made at least $60,000 annually).

Some research has suggested that there are no differences in mental health status between SMW and heterosexual women. We found statistically significant self-reports of lifetime history of depression by sexual orientation in women. We did not find differences in current depression (CESD-R) by sexual orientation in women. In an observational study among sisters (n=184 pairs) no differences between sisters in the prevalence of mental health issues, based on sexual orientation, were found [53]. From the 1996 National Household Survey of Drug Abuse, a sample of about 67 women who reported same-gender partners did not have an increased likelihood of reporting a psychiatric disorder above exclusively heterosexual women [54].

Our research is limited by the variables included in the model. We included variables for energy intake and energy expenditure but there are limits to the variables. The energy intake variable was the mean total caloric intake from a self-report, three-day diary. The Nutrition Data System for Research (NDSR) software was the 2007 version, so all food formulas are tied to that version of the software. While newer NDSR software exists, the food formulas may have changed, so it is not appropriate to update or re-run the data with newer software. The variable for energy expenditure was a broad measure of physical activity. The ESTHER data did not show

significant differences between the sexual orientation of women groups by hours per week of physical activity, or by hours per week of moderate and vigorous physical activity. Group differences by sexual orientation have been investigated using the ESTHER data and no group differences were found for time spent for leisure physical activities (e.g. sports, outdoor activities, etc) or occupational physical activities were found [55]. Future research could consider other mediators or covariates such as childhood sexual abuse, childhood neglect, self-esteem, alcohol use, and others [36]. This research may impact public health in that SMW are a minority group with susceptibility to lifetime psychological distress which can have long-term negative health outcome impacts.

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5.7 DISCLOSURE STATEMENT

No competing financial conflicts exist for any of the authors.

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6.0 OVERALL DISCUSSION

6.1 SUMMARY OF FINDINGS

This dissertation followed the three manuscript approach and all three were secondary data analyses which used data collected in Pittsburgh, PA from the **E**pidemiologic **ST**udy of **HE**alth **R**isk in Women (ESTHER) Project. Broadly all three papers investigated disparities in BMI by sexual orientation in women.

The first Research Article 1 (Section 3.0) utilized the ESTHER three-day food diary data to compare macronutrient intake between SMW and heterosexual women. Unadjusted comparisons by sexual orientation in women were compared and then compared again after adjusting for education level and parity. We discovered there were differences in BMI by sexual orientation in women in the ESTHER sample. We also found dietary intake differences between the groups of women after adjusting for education level and parity. Specifically, total caloric intake, total fat intake, total monounsaturated fatty acid intake, and total polyunsaturated fatty acid intake were statistically higher among SMW than heterosexual women. Intake of alcohol was only statistically higher among SMW than heterosexual women with the unadjusted sample, once we adjusted for education level and parity there were no group differences by sexual orientation in women. To our knowledge, the research was the first study to use three-day food

diary data to explore differences in macronutrient intake between SMW and heterosexual women.

Building from the results of the first Research Article, the second Research Article 2 (Section 4.0) tested mean three-day food diary total caloric intake as a mediator between the sexual orientation in women and BMI and then tested macronutrients (mean grams per day from fats, carbohydrates, protein, and alcohol) as parallel mediators of sexual orientation in women and BMI. We found that sexual orientation is associated with BMI both directly and indirectly through total caloric intake, with the covariates (age, education level, smoking status, and physical activity) held constant. In the parallel mediating model, we found that only fat intake showed partial mediation between the sexual orientation of women and BMI; sexual orientation was statistically related to BMI. To our knowledge, this was the first study to use three-day food diary data to explore the relationship between the sexual orientation of women and BMI and assess potential dietary mediators.

From the first two Research Articles (Sections 3.0 and 4.0) we discovered that there are dietary differences between SMW and heterosexual women and that the dietary differences play a role in the disparities in BMI by sexual orientation in women. What about psychological factors playing a role in the association between the sexual orientation of women and BMI? The minority stress theory model hypothesizes that mental health disparities between sexual minorities and heterosexuals are from a stressful environment created by stigma, prejudice, and discrimination. The excess stress may lead to adverse mental health problems, as outlined by Meyer 2003.

In Research Article 3 (Section 5.0) we explored the relationship between the sexual orientation in women and BMI, specifically investigating the mediating effects of current depression when

the sample was stratified by lifetime history of depression. We found SMW had statistically significant higher rates of both lifetime history of depression and BMI than heterosexual women. We did not find evidence that current depression mediates the relationship between the sexual orientation in women and BMI. Further, we found that women with no lifetime history of depression did not have a statistically significant association between the sexual orientation of women and BMI.

6.2 PUBLIC HEALTH SIGNIFICANCE

Obesity is seen as a leading health indicator, with higher body size associated with increases in all-cause mortality. Obesity is a preventable risk factor associated with the leading cause of death among women, cardiovascular disease (CVD). A specific population of women, SMW, may be at particularly high risk of CVD given their increased risk of obesity when compared to heterosexual women. Existing research suggests SMW have higher BMI than heterosexual women because of their minority stress exposure; SMW are more satisfied with their body type than heterosexual women; differences in exercise patterns between SMW and heterosexual women; and childhood sexual abuse, a risk factor for multiple deleterious health outcomes, is more prevalent among SMW.

But what about dietary consumption? The theories address energy expenditure through hypothesized differences in exercise patterns between SMW and heterosexual women but do not address energy intake. Existing research is limited in comparing differences in dietary consumption to address disparities in body mass index of women by sexual orientation. Our research is novel by contributing analysis using very detailed dietary intake information that

were collected using a three-day food diary. We were able to detail dietary differences between SMW and heterosexual women. We found that there are, in fact, dietary differences between sexual orientation groups of women. For example, SMW had statistically significant higher daily intake of total calories, total fat, total monounsaturated fatty acid, total polyunsaturated fatty acid, than heterosexual women even after adjusting for differences in education and parity. Alcohol consumption is higher among SMW than heterosexual women and we found that to be true in our analysis. However, after adjusting for education and parity, there were no significant differences between alcohol consumption for SMW and heterosexual women.

So if we know there are specific dietary consumption differences between SMW and heterosexual women couldn't those dietary differences explain the relationship between the sexual orientation of women and BMI? We tested the potential mediating factors of dietary consumption in two ways: total caloric intake as a mediator; then macronutrients (mean daily grams of each: fat, carbohydrates, protein, and alcohol) as parallel mediators. We found that sexual orientation was associated with BMI both directly and indirectly through total caloric intake, without covariates and with covariates held constant. In the parallel mediating model without covariates and with covariates (age, education, smoking status, and physical activity) held constant, only fat intake showed partial mediation between the sexual orientation of women and BMI; sexual orientation was statistically related to BMI.

Taking a look back at other reasons SMW may have higher BMI than heterosexual women, existing research suggests minority stress exposure could be a reason. The minority stress theory model hypothesizes that mental health disparities between sexual minorities and heterosexuals are from a stressful environment created by stigma, prejudice, and discrimination. The excess stress may lead to adverse mental health problems. To explore the relationship between the

sexual orientation in women and BMI we investigated the mediating effects of current depression when the sample was stratified by lifetime history of depression. We found SMW had statistically significant higher rates of both lifetime history of depression and BMI than heterosexual women. We did not find evidence that current depression mediates the relationship between the sexual orientation in women and BMI. Further, we found that women with no lifetime history of depression did not have a statistically significant association between the sexual orientation of women and BMI.

Research has traditionally concluded that SMW are disproportionately affected by overweight and obesity compared to heterosexual women. Our novel research delved deeper into factors that may contribute to the BMI disparities by sexual orientation in women.

6.3 STRENGTHS AND LIMITATIONS

As noted in the Background section (2.0), the Institute of Medicine recommended The National Institute of Health (NIH) implement a research agenda designed to advance knowledge and understanding of LGBT health. The ESTHER project collected data from a large group of women, both SMW and heterosexual women. The data are rich and vast, the women who participated in the ESTHER project provided a wide variety of data from questionnaires to biological samples and clinical testing.

Broad conclusions and generalizability should consider the participant criteria which included no history of heart disease, age 35 years or older, living in the Pittsburgh, PA area, and identified as heterosexual or were considered SMW. SMW for the ESTHER project included women who

identified as lesbian or bisexual *and* having emotional, physical, and romantic attractions within the past 5 years toward only or primarily women or whose relationships within the past 5 years had been with only or primarily women. The ESTHER women were also primarily Caucasian, had a high level of education, and had fairly high household incomes. These factors should be considered when applying the findings of this research to other research among SMW.

The ESTHER project data are limited by self-report. The food diary data represents only three days of dietary tracking. The daily report reduces recall bias, but reporting bias may still be possible and the generalizability of a three-day record could be challenged. The Nutrition Data System for Research (NDSR) software was the 2007 version, so all food formulas are tied to that version of the software. While newer NDSR software exists, the food formulas may have changed, so it is not appropriate to update or re-run the data with newer software.

6.4 CONCLUSIONS

The ESTHER project data fills a gap in the LGBT data but more research should be conducted among these minority populations. There is heterogeneity within the LGBT community, and even within the lesbian/SMW community. As reported in the background section (2.1.1) only 0.1% of scientific articles published between 1980 and 1999 included research among the LGBT population. The field is rich with opportunities for discovery and more research is needed to provide insight into sexual minority heath disparities and to better inform development of health intervention programs targeting the community.

From our research specifically, one can see that intervention programs for SMW targeting the management of total caloric intake and fat intake may help with closing the BMI disparity between SMW and heterosexual women. While SMW did consume statistically significant more alcohol than heterosexual women, we found that after adjusting for covariates there was no difference in alcohol consumption by sexual orientation in women.

Intervention programs addressing weight management for SMW that focus on minority stress should consider attention to overcoming lifetime history of depression, not just current depression, as our research found the lifetime history of depression has a significant impact on the relationship between sexual orientation in women and BMI.

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