Patterns, Prevalence, and Determinants of Chronic Disease Disparities in Sexual Minority Women and Men

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Dedication

"I write for those women who do not speak, for those who do not have a voice because they were so terrified, because we are taught to respect fear more than ourselves. We've been taught that silence would save us, but it won't."

— Audre Lorde, 1985

I dedicate this dissertation to my LGBTQ community.

We are essential.

Our lives, our stories, and our truths are essential.

Our health and wellbeing is essential.

I learn because you share your lives, your stories, and your truths.

I write because we deserve solutions that strengthen our collective health and wellbeing.

Thank you for allowing me to use my voice through science to advocate for our community.

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Abstract

Sexual minority women (i.e., women identifying as lesbian or bisexual, or report same-sex behavior; SMW) and sexual minority men (i.e., men identifying as gay or bisexual, or report same-sex behavior; SMM) exhibit disproportionate risk for developing chronic diseases. Yet, the breadth of chronic disease disparities and unique factors that give rise to these disparities in SMW and SMM are unknown. Patterns of chronic disease and determinants may also differ by how sexual orientation is measured; however, few studies address this concern. This dissertation identified patterns, prevalence, and determinants of chronic disease in SMW and SMM.

Chapter 2 systematically reviewed publicly available health surveillance programs that included sexual orientation measures. While 50% of data sources measured sexual orientation, most did not follow best practices set forth by the Williams Institute. Chapter 3 used National Health and Nutrition Examination Survey (NHANES) data to investigate chronic disease disparities SMW and SMM defined by sexual identity, sexual behavior, and in terms of identity and behavior. SMW and SMM evidenced disparities in asthma and chronic bronchitis, arthritis (SMW only), and hypertension (SMM only). Importantly, we identified disparities in “hidden” subgroups of heterosexual men reporting same-sex behavior (MSM). Chapter 4 investigated food insecurity as a determinant of smoking in SMW and SMM using NHANES. Food insecurity was associated with current smoking and smoking intensity in SMW defined by sexual identity and behavior. In SMM defined by sexual identity and lifetime sexual behavior, severe food insecurity was associated with current smoking. SMW—including heterosexual women reporting same-sex behavior (WSW)—and gay men evidenced food insecurity disparities.

This dissertation provides evidence of patterns and determinants of chronic disease disparities in SMW/SMM. Chapter 2 reviews publicly available data sources researchers can leverage to investigate sexual minority health. Chapters 3 advises researchers, medical and public health providers about inflammatory chronic disease disparities experienced by SMW/SMM. Chapter 4 evidence informs tailored cessation interventions to decrease smoking in food insecure sexual minorities. Notably, this dissertation provides population-level evidence for health-related disparities in heterosexual WSW/MSM. This underscores the importance of using multiple sexual orientation measures to identify disparities in sexual minority subgroups.

Preface

"Don't use words too big for the subject. Don't say infinitely when you mean very; otherwise you'll have no word left when you want to talk about something really infinite."

— C.S. Lewis
Letters to Children

"I take as a given that power inheres in the ability to name, and that what we call ourselves has implications for political practice."

— Steve Epstein
Forms of Desire: Sexual Orientation and the Social Constructionist Controversy

Language is essential. Language shapes how we understand the world around us: what we name each other and how we feel about what we are naming. As a health equity researcher, I investigate how social and environmental conditions—including experiences of oppression and discrimination—contribute to population-level health in groups of people whose sexual orientation (i.e., their sexual identity, attractions, or sexual behaviors) is not heterosexual.

The field of sexual orientation-related health disparities is multidisciplinary and there is variance by discipline and across time in how we use language to describe people based on their sexual orientation. Some scholars use the categorical terms "lesbian", "gay", and "bisexual" as a common language for discussing sexuality and same-sex desire. These fixed identity-labels have made sexual orientation—a complex phenomenon—much easier to understand. They also provide a framework wherein researchers can describe disparities in health behaviors and conditions experienced by these identity groups.

However, this categorical shorthand may be detrimental to our study of sexual orientation-related health disparities. First, these categories are limited in scope: Most health surveillance programs measuring sexual identity ask respondents only whether they identify as lesbian, gay, bisexual, or "other". However, people identify across a range of sexual identities that include lesbian, gay, bisexual, queer, pansexual, asexual, omnisexual, sapiosexual, and more. This measurement limitation raises questions: Which sexual identities do we choose to include and exclude in our studies—and why? What nuances do we miss when respondents are forced to choose "other" in health surveys if they do not identify as lesbian, gay, bisexual, or heterosexual?

Second, defining sexual orientation by identity only renders invisible those subgroups of people who may identify as heterosexual but engage in sexual practices or desires that are not heterosexual. Given that same-sex behavior and desire is still not accepted by many conservative and minority communities, these heterosexual individuals with same-sex attractions, or who engage in same-sex behavior, may also experience sexual orientation-related discrimination and related health disparities.

In an attempt to address these concerns, public health researchers have begun using multiple measures of sexual orientation in health studies, including sexual identity, sexual behavior, and attraction. By using multiple sexual orientation measures researchers can more explicitly define groups lesbian, gay, bisexual, and heterosexual people; those who engage in same-sex behavior; or those with same-sex desires. We can also combine measures to identify “hidden subgroups”, such as heterosexual women and men who engage in same-sex behavior (heterosexual WSW and heterosexual MSM).

In addition, instead of relying on “lesbian, gay, bisexual” as a fixed term, many public health researchers and practitioners have embraced “sexual minority” as a term to describe people whose sexual identity, desires, or practices differ from the majority heterosexual society. For health equity researchers, using the language “sexual minority” makes sense, as our primary calling is to investigate patterns of health inequities across historically oppressed and marginalized “minority” populations. “Sexual minority” can include people who identify as lesbian, gay, or bisexual or those who do not identify as lesbian, gay, or bisexual but experience same-sex desire or engage in same-sex behavior. All of these groups differ from majority heterosexual society and, thus, experience sexual orientation-related oppression and discrimination. In this sense, adopting “sexual minority” also creates a leverage point for public health scholars and activists advocating for sexual orientation-based nondiscrimination protections. In an era of increasing “religious freedom” laws that permit sexual orientation-based discrimination in employment, public accommodations, and housing, the need for “minority protections” is real.

From a mathematical perspective, the term “minority” also connotes numeracy. As such, for social epidemiologists the term “sexual minority” makes sense, as these groups are low prevalence populations. Only 3-10% of individuals will report lesbian, gay or bisexual identity; same-sex attraction; or same-sex behavior in population-based surveys. Still, in a country

whose population numbers over 325 million people, 3-10% is an impressive number of individuals.

I have used “sexual minority” in my work to describe diverse sexual orientation groups, which you will see reflected in the title of this dissertation and the published articles arising from my first and second dissertation studies (Chapters 2 and 3). However, as a health equity researcher and queer lesbian, I am uncomfortable using a term that may also be offensive to lesbian, gay and bisexual community members. The term “sexual minority” sets up a linguistic power dynamic that defines “heterosexual” as norm and anyone else as “minority” or “other”. Sexual minorities, thus, only exist in contrast to heterosexuals. The term “sexual minority” thus strips the queer community (here, used to denote groups of people who do not identify as heterosexual) of its independence and ignores the cultural influence of queer people on the mainstream.

So, what to do? One solution is to build on language used to describe other marginalized groups, such as “historically oppressed” or “historically excluded”, to highlight the historical (and contemporary) oppression and marginalization experienced by these groups. A strength of these terms is that they do not render historically oppressed groups as “other” or “minority” and, thus, do use language to further assert power over. I do not take this strategy in this dissertation for two reasons: (1) I began this dissertation project early in my Ph.D. training and adopted “sexual minority” as a term used widely in public health. It has taken publishing two first-authored manuscripts and other co-authored publications to live into my opinions on language. However, as those initial studies form my second and third chapters, for the sake of parsimony I have continued using the term “sexual minority” throughout this dissertation. (2) Sexual minority health research is a growing field and not all “mainstream” scholars are comfortable discussing sexual orientation. The National Institute of Minority Health has adopted the term “sexual minority” and many disparities researchers are increasingly using the term when publishing articles on sexual orientation-based disparities. While convention does not always connote best practice, for an emerging scholar conducting research in an underrepresented field, adopting the term “sexual minority” allows me to engage with mainstream scholars *where they are at this time*. Do I think our language needs to change? Yes. Do I plan to write commentaries to that effect? Yes. However, at this time and for the sake of moving conversations about sexual orientation-related health disparities forward, I am choosing to write and publish within an existing and commonly used framework.

Beyond adopting terms like “sexual minority”, another strategy for health equity researchers is to specifically and consistently describe the terms by which sexual orientation is defined in our studies—whether by self-identification, same-sex behavior, or attraction. In this dissertation, I specifically define the parameters by which sexual orientation is operationalized in my research and in that of other scholars. As such, you will see the terms “sexual minority”; “sexual minorities”; “sexual minority people”; “lesbian, gay, and bisexual” (LGB); “lesbian, gay, bisexual, and transgender” (LGBT); and “same-sex”. I also name the specific sexual orientation measures I include in my analyses; for example, when sexual orientation is defined by identity only (e.g., lesbian, gay, bisexual) or in terms of sexual identity and sexual behavior (e.g., heterosexual WSW and heterosexual MSM). My hope is that by specifically defining these parameters I reduce confusion for readers whose expertise is not in sexual orientation-related research.

As I develop as a health equity scholar, I imagine my language will change as it has throughout the course of my doctoral study and this dissertation. As a queer scholar conducting sexual orientation-related research, I must consider (1) how I use language to describe sexual orientation and (2) whether my language supports or marginalizes people who embrace sexual identities, attractions, or behaviors beyond heterosexuality. Over time, as our field grows, I have faith that our language to describe sexual orientation will also grow. Until then, I will engage in transparent dialogue about language—in my research, service, and teaching—as part of my greater commitment to increasing health equity for people of diverse sexual orientations.

Joanne Gayle Patterson

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List of Abbreviations

ABAWD	Able-bodied adults without dependents
ACS	American Community Survey
Add Health	National Longitudinal Study of Adolescent to Adult Health
ALSWH	Australian Longitudinal Study on Women's Health
aOR	Adjusted odds ratio
BMI	Body mass index
BRFSS	Behavioral Risk Factor Surveillance System
CCHS	Canadian Community Health Survey
CEI	Corporate Equality Index
CI	Confidence interval
CLRD	Chronic lower respiratory disease
CMS	Centers for Medicare and Medicaid Services
CPS	Current Population Survey
CVD	Cardiovascular disease
CWHS	California Women's Health Survey
DAG	Directed acyclic graph
DL	Down low
EITC	Earned income tax credit
FPL	Federal poverty line
GenIUSS	Gender Identity in U.S. Surveillance
GUTS	Growing Up Today Study
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
HPA	Hypothalamic pituitary adrenal
HRC	Human Rights Campaign
HUD	Housing and Urban Development
IOM	Institute of Medicine
IRR	Incidence rate ratio
KPMHS	Kaiser Permanente Member Health Survey
LACHS	Los Angeles County Health Survey
LGB	Lesbian, gay, bisexual
LGBT	Lesbian, gay, bisexual, transgender
LGBTQ	Lesbian, gay, bisexual, transgender, queer

LR X2	Likelihood ratio chi-squared
MIDUS	Midlife Development in the United States
MSA	Minimally sufficient adjustment set
MSM	Men who report having sex with men
MSS	Minnesota Student Survey
NAS	National Alcohol Survey
NATS	National Adults Tobacco Survey
Natsal	National Survey of Sexual Attitudes and Lifestyles
NCHA	National College Health Assessment
NCS	National Comorbidity Survey
NDI	National Death Index
NDSHS	National Drug Strategy Household Survey
NESARC	National Epidemiologic Survey on Alcohol and Related Conditions
NHANES	National Health and Nutrition Examination Survey
NHIS	National Health Interview Survey
NHS II	Nurses' Health Study II
NHSLS	National Health and Social Life Survey
NIH	National Institutes of Health
NISVS	National Intimate Partner Violence and Sexual Violence Survey
NLAAS	National Latino and Asian American Study
n.s.	Not significant
NSDUH	National Survey on Drug Use and Health
NSHAP	National Social Life, Health, and Aging Project
NVAW	National Violence Against Women Survey
NYC CHS	New York City Community Health Survey
NYC HANES	New York City Health and Nutrition Examination Survey
P-value	Probability value
PHQ-9	Patient Health Questionnaire-9
PIR	Family poverty to income ratio
PHDCN	Project on Human Development in Chicago Neighborhoods
POC	People of color
RFRA	Religious freedom restoration act (also called "religious freedom laws")
SEER	Surveillance, Epidemiology, and End Results
SGM	Sexual and gender minorities

SGMRO	Sexual and Gender Minority Research Office
SID	Smoking-induced deprivation
SMART	Sexual Minority Assessment Research Team
SMM	Sexual minority men
SMP	Sexual minority people
SMW	Sexual minority women
SNAP	Supplemental Nutrition Assistance Program
SOGI	Sexual orientation and gender identity
SSA	Social Security Administration
TANF	Temporary Assistance for Needy Families
TTFC	Time to first cigarette
TGNC	Transgender and gender non-conforming
US	United States
USA	United States of America
USDA	United States Department of Agriculture
WHI	Women's Health Initiative
WIC	Women, Infants, and Children
WSW	Women who report having sex with women
X2	Chi-squared
YRBSS	Youth Risk Behavior Surveillance System

Chapter 1

Chronic Disease Disparities in Sexual Minority Populations: Why Study Patterns, Prevalence, and Determinants

Introduction

A growing body of evidence—including several systematic reviews and two Institute of Medicine reports[1,2]—indicates that sexual minority women (SMW women who identify as lesbian or bisexual, experience same-sex attraction, or engage in same-sex sexual behavior) and sexual minority men (SMM; men who identify as gay or bisexual, experience same-sex attraction, or engage in same-sex sexual behavior) experience higher prevalence of preventable chronic disease than their heterosexual counterparts. Lesbian and bisexual women demonstrate increased risk for cardiovascular disease (CVD)[3,4] and breast, cervical, ovarian, and lung cancer specifically,[5,6] as well as increased prevalence of cancer diagnosis in general,[3] asthma,[7,8] and arthritis.[8] Similarly, gay and bisexual men demonstrate increased risk for CVD,[3] anal and lung cancer,[5,6] and increased prevalence of cancer diagnosis in general.[3]

Measuring Sexual Minority Chronic Disease Disparities

In most population-level studies of chronic disease disparities in sexual minority adults, sexual orientation is determined by a single measure of sexual identity; that is, whether someone self-identifies as lesbian, gay, bisexual (LGB), or heterosexual. This is problematic as sexual orientation is a multidimensional construct that comprises a person's sexual identity,[9] attractions,[10] and sexual behavior[9] (Figure 1.1). Accordingly, a person's sexual orientation can be described by any combination of these dimensions. For example, a woman may identify as lesbian and report exclusively same-sex behavior (lesbian woman who has sex with women; WSW). Another woman may identify as heterosexual and report exclusively heterosexual sexual behavior (heterosexual woman who has sex with men; WSM). A third woman may identify as heterosexual and report same-sex and heterosexual sexual behavior (heterosexual WSW). Thus, if we define sexual orientation only by sexual identity, we risk excluding "hidden" groups of sexual minorities—such as sexual heterosexual WSW.

Minority stress theory—the prevailing explanation for health disparities in SMW and SMM—suggests that patterns of health disparities may vary across diverse subgroups of sexual minorities (e.g., lesbian WSW vs heterosexual WSW).[11] In the context of the minority stress model, SMW and SMM are assumed to experience stressors related specifically to their non-heterosexual sexual orientation that drive risk behaviors and related health outcomes.[11] Theoretically, minority stressors are proximal (e.g., internalized homophobia) and distal (e.g., experiencing discrimination and victimization). Proximal stressors are dependent on a person's

self-identification as lesbian, gay, or bisexual. Distal stressors are objective experiences of discrimination based on a person's actual or perceived non-heterosexual sexual orientation.[11] Individuals who self-identify as LGB may experience both proximal and distal minority stressors. However, heterosexual women and men who engage in same-sex behavior (heterosexual WSW and heterosexual MSM) may also experience minority stress. For example, heterosexual WSW/MSM may hide same-sex behavior because they fear discrimination from family and friends who assume that their heterosexual identity confers heterosexual sexual behavior.[12-14] Studies document this experience in Black, Latino, and rural communities where same-sex behavior is not widely accepted.[15-18] It is entirely possible that heterosexual WSW/MSM from these communities—and others where same-sex behavior is not accepted—may confer risk for poor health arising from distal minority stress. As such, researchers must consider how sexual orientation measures included in population-level health surveillance include or exclude diverse subgroups of SMW and SMM, such as heterosexual WSW/MSM.

Best practices set forth by the Williams Institute Sexual Minority Assessment Research Team (SMART) recommend that health disparities researchers measure multiple dimensions of sexual orientation—specifically, identity, behavior, and attraction—in population-level studies of health disparities.[19] Measuring any one or all of these dimensions includes different subgroups of SMW and SMM, each with potentially different prevalence of and mechanisms for health disparities related to sexual orientation. Investigating differences in diverse subgroups of sexual minorities defined by more than one sexual orientation measure (e.g., sexual identity and sexual behavior) may reveal important nuances about chronic disease disparities.

One barrier to examining chronic disease disparities in SMW and SMM is that not all population-level health surveillance measures sexual orientation. As such, disparities studies are limited to primary data collection or the publicly available data sources that do measures sexual orientation. To date, there is no comprehensive resource documenting which publicly available health surveillance data sources measure sexual orientation nor which measures they include (i.e., identity, behavior, attraction). To facilitate sexual minority health research, and to advance knowledge about chronic disease disparities in subgroups of sexual minorities, a scholarly resource that reviews the publicly available data sources that include sexual orientation is needed. Aim 1 of this dissertation project will address this issue by (1) systematically reviewing publicly available, health surveillance data sources that include measures of sexual orientation

and (2) comparing sexual orientation measures to best practice recommendations for measuring sexual orientation as set forth by the Williams Institute SMART.

Documenting Patterns of Chronic Disease

While most studies documenting chronic disease disparities define sexual orientation by sexual identity measures alone, preliminary evidence indicates that measuring sexual orientation with both sexual identity and sexual behavior measures reveals nuances about chronic disease patterns among sexual minority subgroups.[20,21] Two studies to date have combined measures of sexual identity and sexual behavior to examine disparities in heterosexuals with a history of same-sex sexual behavior. Using California Quality of Life data, Cochran and Mays (2007) determined that heterosexual women with a history of same-sex sexual behavior (heterosexual women who have sex with women; heterosexual WSW) were almost thrice as likely to have asthma as exclusively heterosexual women. Moreover, self-identified heterosexual men with a history of same-sex sexual behavior (heterosexual men who have sex with men; heterosexual MSM) were 3.45 times more likely to report asthma and 6.28 times more likely to report CVD than exclusively heterosexual men.[20] In a second study using national health surveillance data, more heterosexual MSM reported having diabetes (5.5%) than exclusively heterosexual men (4.4%).[21] Both of these studies provide evidence for using multiple measures of sexual orientation when investigating health disparities: Without defining sexual orientation in terms of sexual identity and sexual behavior, researchers would be unaware that heterosexual WSW and heterosexual MSM also experience chronic disease disparities.

Nonetheless, these studies have limitations. The first used state-level health surveillance data to produce prevalence estimates; however, it is unknown whether state level estimates accurately reflect chronic disease disparities in SMW and SMM across the United States (U.S). As such, studies examining chronic disease disparities using national population-level health surveillance are warranted. While the second study used national-level health surveillance data, it only examined CVD in men. Thus, the breadth of preventable chronic diseases that SMW and SMM across the U.S. may experience is currently unknown. Together these studies highlight the need for research that captures subgroups of sexual minority people by using multiple measures of sexual orientation to assess patterns of preventable chronic disease. Aim 2 of this dissertation project will address this concern by using the National Health and Nutrition Examination Survey (NHANES) to investigate chronic disease prevalence in SMW and SMM defined by sexual identity, sexual behavior, and in terms of sexual identity and sexual behavior.

Examining Determinants of Chronic Disease

Once patterns of chronic disease in sexual minorities are better understood, it is imperative that researchers investigate determinants that give rise to chronic disease disparities within at-risk subgroups of SMW and SMM. To date, there is little empirical evidence identifying specific risk and protective factors for chronic diseases in subgroups of sexual minority people.[22] Using Massachusetts' Behavioral Risk Factor Surveillance System data pooled from 2001-2008, Landers et al. (2011) determined sexual minority participants reporting current/former cigarette smoking were 72% more likely to have an asthma diagnosis (aOR = 1.72; 95% CI, 1.01, 2.98) while obese sexual minority people were over twice as likely to have asthma (aOR = 2.19; 95% CI, 1.16, 4.31).[23] While this study provides evidence for risk behaviors as contributing factors for asthma diagnosis, subgroup analyses (e.g., lesbian vs. bisexual women) were not considered. In contrast, using national health surveillance data, Farmer et al. (2013) examined CVD risk among women by sexual identity subgroup. Results indicated that demographic characteristics, alcohol, and smoking explained much but not all of lesbian and bisexual women's increased risk for CVD.[24] Additionally, in a second study, Farmer et al.(2013) determined that bisexual men had increased risk for CVD compared to heterosexual men, and that education and hard drug use accounted for much of this difference.[21] Both of these studies suggest that subgroups of sexual minority people experience risk and protective factors for chronic disease documented in the general population, including sociodemographic characteristics and risk behaviors. Results also indicate that risk behaviors—including cigarette use, alcohol, and obesity—account for much of these disparities. However, to date, no published population-based studies document determinants of chronic disease in subgroups of sexual minority people defined by discrete and overlapping measures of sexual orientation (i.e., sexual identity and behavior).

One explanation for the limited number of studies investigating mechanisms leading to chronic disease is that chronic disease arises mostly in older adults. Evidence to date suggests that sexual orientation-inclusive population-level health surveillance programs either (1) restrict sexual orientation measurement by age to adults less than age 60 years, or (2) without oversampling, include too few sexual minority older adults to adequately power analyses.[1,25] One strategy is to pool health surveillance data sources across locations or over time to produce sample sizes adequate for analysis. A second strategy for increasing sample size is to investigate determinants contributing to risk factors for preventable chronic diseases. For example, approximately 17.9% of self-identified SMW and 23.8% of self-identified SMM report current cigarette smoking,[26] which is the leading cause of preventable chronic disease.[27] By

investigating determinants contributing to cigarette smoking, it is more likely that researchers will be able to power explanatory analyses. In turn, identifying modifiable determinants of smoking disparities may help researchers develop and implement interventions to reduce cigarette smoking and, ultimately, tobacco-related chronic disease disparities.

To date, studies have identified multiple demographic characteristics (age,[28,29] education level,[28,29] lack of health insurance[30]), psychosocial factors (frequent bar attendance,[30] alcohol use,[28,29] illegal drug use,[28,29] poor mental health, childhood physical abuse[28]), and minority stressors (victimization,[31] threat of violence,[31] discrimination[32]) that may explain cigarette smoking in sexual minority groups. However, only two published population-based studies have examined specific pathways predicting cigarette smoking in sexual minority adults.[33,34] In both studies, sexual orientation had a direct effect on smoking, and indirect effects were found across various sexual minority subgroups via depression,[34] poor mental health,[33] heavy alcohol use,[33,34] and limited healthcare access.[33,34] However, even together and controlling for sociodemographic characteristics, these variables did not wholly explain cigarette smoking disparities in SMW and SMM.[33,34] As such, studies examining factors that may further explain sexual orientation disparities in cigarette smoking are necessitated.

Food security is an understudied mechanism that may contribute to smoking. Defined as "access by all people at all times to enough food for an active, healthy life", food security is in independently associated with cigarette smoking in the general adult population.[35-38] Estimates indicate that individuals who are food insecure (meaning that they do not have access to enough food for a healthy, active lifestyle) are 1.20-1.77 times more likely to smoke than those who are food secure.[35,36,39] In one longitudinal study, nonsmokers who became food insecure, were 3.77 times more likely to start smoking by follow-up than those remaining food secure.[40] Moreover, smokers who became food insecure were 0.66 times less likely to quit smoking by follow-up. Conversely, smokers who were food insecure at baseline but became food secure were 1.20 times more likely to quit smoking by follow-up.[40] Alarmingly, these disparities persist even when controlling for demographic (i.e., age, gender, race/ethnicity, marital status), economic (i.e., employment status, income, housing insecurity, limited health insurance), psychosocial (i.e., distress), and behavioral (i.e., alcohol use) factors.[35,36,39,40] Given this evidence, it may be that food insecurity is also associated with smoking in SMW and SMM; however, no studies to date have investigated this issue. Aim 3 of this dissertation project will

address this gap by using the National Health and Nutrition Examination Survey to investigate associations between food insecurity and smoking behaviors in SMW and SMM.

Food Insecurity in SMW and SMM

Using a multilevel model and drawing upon Fundamental Cause Theory,[41,42] Warnecke et al. (2008) suggest that inequitable social conditions that give rise to discrimination are fundamental causes of health disparities. In this model, disparities persist because inequitable social conditions influence access to resources that can be used to prevent or attenuate poor health outcomes—including risk behaviors.[43] For SMW and SMM, inequitable social conditions in the form of heterosexist and homophobic social norms and policy are hypothesized to deplete social and economic resources that can be used to prevent or attenuate poor health outcomes. Resources depleted by inequitable social conditions may include employment and wages, social connections, and interpersonal influence (i.e., power).[44,45] These contextual factors interact with intersecting minority identities (e.g., gender, race/ethnicity) to influence individual-level socioeconomic risk factors (e.g., poverty status, access to health insurance) and psychosocial risk and coping behaviors (e.g., smoking), ultimately resulting in disparate disease outcomes. To eliminate disparities, policies and interventions must address inequitable social conditions; however, in the absence of comprehensive policy or social change, we must identify modifiable determinants that may be intervened upon at a population-level.

In the U.S. food insecurity is considered an indicator of economic stability,[35] yet the United States Department of Agriculture food security measure assesses socioeconomic, psychosocial, and health-related dimensions of food insecurity. Specific question enquire about respondents' ability to afford food, lived experiences of food insufficiency, anxiety about food insufficiency, coping strategies for managing food insufficiency, and health consequences of food insufficiency.[36] As such, we consider food insecurity a complex construct that exists at the intersection of socioeconomic and psychosocial factors.

Warnecke's model and fundamental cause theory suggest that sexual minority people are at greater risk for experiencing food insecurity than heterosexuals due to depletion of social and economic resources arising from inequitable social conditions. To date, only two published reports have investigated food insecurity in sexual minorities using population-level data from multiple health surveillance data sources, including Gallup Daily Tracking[46,47] and the National Health Interview Survey[47] Results indicated that almost 1 in 3 lesbian, gay, bisexual, and

transgender (LGBT) adults reported not having enough money for food at some time of the past 12-months.[46,47] Moreover, these disparities persisted across gender, age, educational, and racial/ethnic subgroups where LGBT people were 62-67% more likely to report not having enough money to pay for food than non-LGBT people.[46,47] Results from the NHIS also indicated that almost 1 in 5 LGB adults reported that they or another family member went without food for an entire day in the past 30 days, and 1 in 7 LGB adults reported running out of food and not having money to purchase more in the past 30 days.[47] While food insecurity is a multidimensional construct, of which lack of food and not having enough money to pay for food are but two components, together these data indicate that sexual minorities may evidence food insecurity disparities. However, studies using comprehensive measures of food insecurity are needed to ascertain disparities in diverse subgroups of SMW and SMM. Our study will address this gap by investigating food insecurity disparities in diverse subgroups of SMW and SMM.

Dissertation Aims

According to the Centers for Disease Control, "public health is the science of protecting and improving the health of people."[48] It is with this task in mind that I present the following dissertation project investigating patterns, prevalence, and disparities of chronic disease disparities in sexual minority populations. It is only with further scientific inquiry that identifies the unique and modifiable risk factors for chronic disease in diverse subgroups of SMW and SMM that we can successfully implement effective, culturally relevant, intervention and prevention strategies to improve health for this group.

1. Review the existing English language, publicly available health surveillance data sources that include measures of sexual orientation.
    - Aim 1: Describe existing publicly available health surveillance data sources that include measures of sexual orientation.
    - Aim 2. Among health surveillance data sources that measure sexual orientation, compare sexual orientation measures with best practice guidelines as set forth by the Williams Institute SMART.

2. Investigate differences in chronic disease disparities in sexual minority women and men using publicly available, population-based health surveillance.

- Aim 1: Describe chronic disease disparities in diverse sexual orientation subgroups defined by sexual identity and sexual behavior, and stratified by gender.
  Hypothesis 1: Chronic disease prevalence estimates will be higher in self-identified SMW and SMM than among sexual minorities measured by sexual behavior.

3. Investigate food insecurity as a determinant of cigarette smoking in SMW and SMM using publicly available, population-based health surveillance.
   - Aim 1: Determine associations between food insecurity and smoking behaviors in sexual minority women and men.
     Hypothesis 1: SMW and SMM experiencing food insecurity will evidence greater cigarette smoking than food secure SMW and SMM.
     Hypothesis 2: SMW and SMM experiencing severe food insecurity will evidence greater cigarette smoking than food secure SMW and SMM.
     Question 1. How is food security associated with nicotine dependence and cigarette smoking intensity in SMW and SMM who smoke?
   - Aim 2: Investigate disparities in food security experienced by subgroups of SMW and SMM defined by sexual identity only and in terms of sexual identity and behavior using a comprehensive measure of food security.
     Hypothesis 3: SMW and SMM will evidence greater food insecurity than heterosexuals.
     Question 2: How do disparities in food insecurity vary by how we define sexual orientation (i.e., by sexual identity only or in terms of sexual identity and behavior)?
     Question 3. How do disparities in food insecurity vary by sexual orientation subgroup (e.g., lesbian vs bisexual vs. heterosexual women)?

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Appendix. Figures and Tables

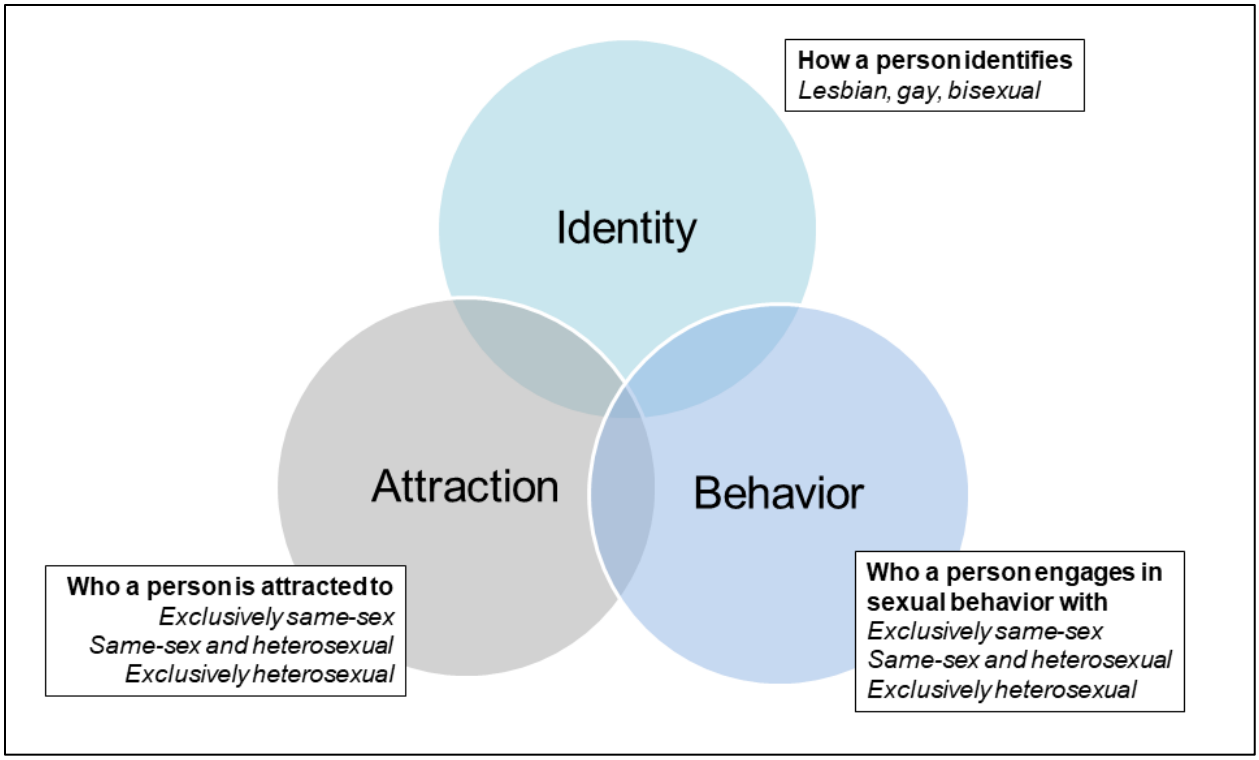

Figure 1.1 Dimensions of sexual orientation

Chapter 2

Measuring Sexual and Gender Minority Populations in Health Surveillance

This chapter represents a manuscript published by Joanne G. Patterson, Jennifer M. Jabson, and Deborah J. Bowen:

> Patterson, J. G., Jabson, J. M., & Bowen, D. J. (2017). Measuring sexual and gender minority populations in health surveillance. LGBT health, 4(2), 82-105. doi: 10.1089/lgbt.2016.0026

My contributions to this manuscript as the lead author include: (1) identifying the gap in the existing literature, (2) developing research questions, (3) designing study and analyses, (4) analyzing and interpreting quantitative data, and (5) primary authorship and editing of the final manuscript.

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Abstract

Purpose

Sexual and gender minorities (SGMs) are underrepresented and information about SGMs is difficult to locate in national health surveillance data, and this limits identification and resolution of SGM health disparities. It is also not known how measures of sexual orientation and transgender-inclusive gender identity in health surveillance compare with best practice recommendations. This article reviews and summarizes the publicly available, English language, large-scale, rigorously sampled, national, international, and regional data sources that include sexual orientation or transgender-inclusive gender identity and compares measures with best practice guidelines.

Methods

A systematic review was undertaken of national, international, state, and regional health surveillance data sources. Data sources that measured sexual orientation or transgender-inclusive gender identity and met seven inclusion criteria were included.

Results

Forty-three publicly accessible national, international, and regional data sources included measures of sexual orientation and transgender-inclusive gender identity and health. For each data source, sampling design, sample characteristics, study years, survey questions, contact persons, and data access links are provided. Few data sources met best practice recommendations for SGM measurement: 14% measured all three dimensions of sexual orientation (identity, behavior, attraction) as recommended by the Sexual Minority Assessment Research Team. No data sources measured transgender-inclusive gender identity according to the Gender Identity in U.S. Surveillance-recommended two-step method of measuring sex assigned at birth and current gender identity.

Conclusions

This article provides a much needed detailed summary of extant health surveillance data sources that can be used to inform research about health risks and disparities among SGM populations. Future recommendations are for more rigorous measurement and oversampling to advance what is known about SGM health disparities and guide development of interventions to reduce disparities.

Introduction

The 2011 Institute of Medicine (IOM) report on The Health of Lesbian, Gay, Bisexual, and Transgender People summarized growing and consistent evidence of health disparities among sexual and gender minority (SGM) people.1 The landmark report called for the use of rigorous, population-based, observational, and cohort studies of health, among these groups, to expand what is known about SGM health disparities and guide policies and interventions to reduce disparities.[1]

Rigorous, large-scale data sources regarding SGM health are in relative short supply,[1,2] and several national public health surveillance programs do not contain questions regarding respondents' SGM status. For example, the Surveillance, Epidemiology, and End Results (SEER) program, the nation's comprehensive source of cancer incidence and survival data, does not include sexual orientation or transgender-inclusive gender identity measures.[2] General health surveys designed to sample and chart the health status of specific populations, including the Behavioral Risk Factor Surveillance System (BRFSS)[3] and National Survey on Drug Use and Health (NSDUH),[4] have not always measured sexual orientation or transgender-inclusive gender identity. In addition, despite their importance for identifying predictors of disease, few population-based, observational, and cohort studies recruit specifically for SGM participants, nor do they include questions regarding participants' SGM status. These omissions make analyses by sexual minority and/or gender minority characteristics impossible. Excluding demographic questions regarding sexual orientation and transgender-inclusive gender identity from public health surveillance perpetuates the status quo, whereby SGM groups are underserved and knowledge about their physical and mental health is lacking. The relative paucity of knowledge from rigorous, large-scale health surveillance regarding the health of SGM individuals marginalizes these populations by masking potential disparities in health and health behaviors, making it difficult to secure funding for health enhancing programs, and impossible to develop quality solutions that can reduce or eliminate costly health disparities.

A few national and regional data sources, including some federally funded surveillance programs, measure sexual orientation and transgender-inclusive gender identity: these data sources have played an important role in advancing SGM health research.[1] However, there is no comprehensive, scholarly published resource that allows researchers to easily determine which data sources contain information on SGM people. This is problematic. Without a detailed

summary of available SGM population health surveillance, it is time-consuming and challenging to locate quality preexisting data sources to inform research on SGM health and health disparities.

A detailed report would add to existing listings of sexual minority-inclusive datasets[5] by providing a summary of publicly available, large-scale health surveillance resources that measure sexual orientation or transgender-inclusive gender identity as well as those that measure both sexual orientation and transgender-inclusive gender identity, from which researchers can easily (1) find available SGM-inclusive health surveillance systems, (2) identify gaps and opportunities for future SGM health surveillance, and (3) track future progress in the collection of SGM health surveillance data.

While best practice recommendations for measuring sexual orientation and transgender-inclusive gender identity have been published,[1,6,7] there is no published scholarly resource that allows researchers to see how sexual orientation or transgender-inclusive gender identity is measured across data sources.

To measure sexual orientation, the Williams Institute Sexual Minority Assessment Research Team (SMART) considered three dimensions: sexual identity, sexual behavior, and attraction.[6] Measuring any one or all of these dimensions captures different subgroups of individuals, each with potentially different levels of and mechanisms for health risk related to sexual orientation. Therefore, SMART recommends including sexual orientation measures according to study aims. Sexual orientation measures of identity, behavior, and attraction should be selected specifically to capture the individual subgroups of interest.[6] For example, health surveillance surveys used to estimate population health may include questions that capture all three dimensions of sexual orientation to explore the relationships between multiple aspects of sexual orientation and physical, sexual, and mental health in the population.[6]

To measure transgender-inclusive gender identity, the Williams Institute Gender Identity in U.S. Surveillance (GenIUSS) group recommends a two-step approach. The two-step approach includes measuring self-reported assigned sex at birth (sex recorded on the original birth certificate) and current gender identity (at time of survey).[7] When a two-step method cannot be used, a single demographic item that measures self-reported gender identity (at time of survey) is recommended. This measure should include multiple, specific response options for

transgender-inclusive gender identity; that is, transgender, male to female; transgender, female to male; transgender, gender nonconforming; and not transgender.[7]

This article reviews and presents the publicly available, rigorously sampled data sources that include sexual orientation or transgender-inclusive gender identity. In the interest of presenting a comprehensive picture of the state of SGM health surveillance, international, national, and regional data sources are included. We compare specific measures of sexual orientation and transgender-inclusive gender identity with best practice recommendations[6,7] to determine how data sources differ from each other and best practice.

It is important to note that while SMART[6] and GenIUSS[7] recommendations were developed in English by SGM researchers and experts in the United States, they represent the best available, comprehensive published guidelines for SGM measurement domestically and internationally. Thus, assessing international and domestic health surveillance data sources published and distributed in the English language by these standards is a logical first step toward documenting and assessing data sources that measure SGM status. All data sources presented here include sexual orientation measures, but not all data sources measure transgender inclusive gender identity. Therefore, information regarding specific SGM measures is presented separately.

Methods

Search Strategy

Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines were followed for this systematic review.[8] A twofold approach was used to identify SGM inclusive data sources. First, data sources were identified through a comprehensive online search of electronic data warehouses. Warehouses to be searched were determined a priori based on their focus on either SGM health or large-scale health surveillance and included the Population Research in Sexual Minority Health data archive at the Interuniversity Consortium for Political and Social Research,[9] LGBTData.com by Dr. Randall Sell at Drexel University,[5] and the U.S. Government's open data site, Data.gov.[10]

Second, a literature search was performed on August 16, 2016, using the National Library of Medicine's PubMed database (National Center for Biotechnology Information, U.S. National Library of Medicine, USA). Publication dates were limited to January 1, 1990, through

December 31, 2015. After determining our inclusion and exclusion criteria, we conducted a broad preliminary search of articles on SGM health to identify key search terms that described said inclusion and exclusion criteria. Specifically, we searched on pairs of terms that defined SGM (including LGBT, GLBT, lesbian, gay, bisexual, transgender, sexual minority, and gender minority) and health (N= 13,191), SGM and disparities (N= 1184), and SGM and health behavior (N= 4654).

Through this preliminary search, we identified key terms that described our inclusion and exclusion criteria. We specified that LGB*, GLB*, gay, lesbian, bisexual*, transgender, transsexual*, homo*, gender minority, or sexual minority appear in the title and/or abstract and specifically did not include certain terms unrelated to large-scale health surveillance or the objective of this review to obtain only the most relevant articles (search strategy available upon request). For example, we excluded articles including the terms ‘‘systematic review,’’ ‘‘meta-analysis,’’ ‘‘case study,’’ ‘‘case series,’’ and ‘‘clinical trial’’ in their title and/or abstract. The search was restricted to English language articles for which full text was available and that included human subjects.

Inclusion Criteria. Data sources selected for inclusion in this search met the following criteria: (1) measured sexual or gender minority status, including a measure of at least one dimension of sexual orientation (identity, behavior, or attraction), a transgender-inclusive gender identity measure, or a mechanism to enable identification of same-sex household partnerships; (2) focused upon health or household demography; (3) had publicly available data source documentation and survey questionnaires; (4) had data sources that were available to researchers for reanalysis; (5) were conducted between 1990 and 2015; (6) had a sample size of at least 1000; and (7) were conducted and published in the English language. In addition to U.S. national and regional data sources, international data sources meeting selection criteria were included.

SGM Measurement

We defined sexual orientation according to best practices for survey development.[6] Three categories comprised sexual minority orientation: identity, those who identify as homosexual, lesbian, gay, or bisexual; behavior, those who have engaged in same-gender sexual behavior in their lives; and attraction, those who have experienced same-gender attraction. While not recommended as a best practice for measuring sexual orientation,[6] we defined same-sex-

inclusive partner status as a measure of sexual minority cohabitation/marital status. Gender minority status was defined according to best practice recommendations as those who identify as transgender as well as those who endorse another nonbinary gender identity, but do not identify as transgender.[7]

To assess inclusion of SGM measures, survey questionnaires were collected for each data source. Counts and percentages of surveys that included SGM measures were calculated. For all data sources, the specific SGM measurement type(s) used—as defined by inclusion criteria—and total number of SGM measures were counted.

The specific SGM measures included in each survey were compared qualitatively with SMART and GenIUSS best practice recommendations. Counts and percentages of surveys that met specific SGM measurement recommendations were calculated.

All data sources and surveys were publicly accessible as of December 1, 2015. This project did not involve human subjects and did not require approval by the University of Tennessee Institutional Review Board.

Results

Figure 1 presents the flow-diagram for our targeted Web and PubMed searches to identify potential SGM-inclusive public health surveillance data sources. Our Web search identified 28 data sources for inclusion; 3 were international sources; and 25 were U.S. specific. Of U.S.-specific data sources, 16 were nationally representative in scope and 9 were not. The PubMed search identified 3237 articles. Through title and abstract review provided by coauthors (J.P., J.J.), 2752 of the original 3237 articles were identified as not meeting inclusion criteria. Full-text review of the remaining 485 articles identified 20 articles, representing 15 data sources that were eligible for inclusion. Reasons for exclusion were (1) not publicly available (337 articles), (2) not conducted and published in English (63 articles), (3) did not measure SGMs specifically (42 articles), or (4) data sources were identified previously in the Web search (23 articles). Of the 15 eligible data sources identified in the literature review, 4 were international and 11 were U.S. specific. Of U.S. data sources, 5 were nationally representative and 6 were not. Combining results from the Web and PubMed searches, a total of 7 international and 36 U.S.-specific (21 national and 15 regional) data sources were identified.

Summary of Data Source Measures

Tables 1[3,4,11–60] and 2[3,14,21,23,29,31–33,42,45,59] summarize the 43 data sources identified by this review. Table 1 presents data sources that include sexual orientation measures and Table 2 presents data sources that include transgender inclusive gender identity measures. Numerous measures were used to assess sexual orientation, including sexual identity, sexual behavior, attraction, and partner status, utilizing varied question formats (e.g., 5-year versus lifetime sexual behavior). Transgender-inclusive gender identity was most commonly evaluated using a single transgender-inclusive gender identity item.

Table 1 presents the specific items used to assess sexual orientation. All three dimensions of sexual orientation (sexual identity, sexual behavior, and attraction)[6] were measured in 14% of data sources[4,11,38,40,44,47]; 37% measured only two of these dimensions.[15–17,20,21,24,30–36,39,42,43,48–50,52,53,60] Of data sources measuring only two dimensions of sexual orientation, the most frequent pair of measures used were sexual identity and sexual behavior—present in 35% of data sources.[15–17,20,24,30–36,39,42,43,48–50,52,53,60] Forty percent of data sources measured a single dimension of sexual orientation.[3,13,14,18,22,23,25–29,37,41,45,46,54–56,58,59] Of those measuring a single dimension, 12 data sources (28% of all sources) measured sexual identity.[3,13,14,18,22,23,25-27,29,37,41,45,54,55]

Overall, sexual identity was the most common sexual orientation measure and was included in 33 (77%) of the 43 data sources.[3,4,11,13–18,20,22–27,29–45,47–50,52–55,60] Sexual behavior was the next most common measure, included in 25 (58%) of the 43 data sources.[4,11,15–17,20,21,24,28,30–36,38–40,42–44,46–50,52,53,58,60]

The language used by each of the specific items measuring sexual behavior varied greatly between data sources. Most data sources measuring sexual behavior included 12-month[4,11,15–17,20,24,28,31–33,39,40,43,44,47,52] or lifetime[11,17,20,21,38–40,42,44,47–50,53,58,60] same-sex sexual behavior items. Of the 25 data sources measuring sexual behavior,[4,11,15–17,20,21,24,28,30–36,38–40,42–44,46–50,52,53,58,60] only 9 (36%) used at least two sexual behavior items and thus captured sexual behavior over multiple time periods.[11,15,17,20,39,40,44,47,58] Partner status was measured in 13 (30%) data sources.[12,13,19,21,25–27,34–36,40,41,44,46,47,51,57] Four sources solely measured partner status[12,19,51,57]; three of these used U.S. census data for their sampling frame.[12,19,57]

Table 2 presents specific questions used to assess respondent gender identity. Transgender-inclusive gender identity questions were present in 8 (19%) of the 43 data sources.[3,14,21,23,29,31–33,42,45,59] Most of these data sources used a single item to measure transgender-inclusive gender identity (e.g., Do you identify as male, female, or transgender?).[3,14,21,23,29,42,45,59] One data source used two items to measure gender minority identity.33 No data sources followed best practice recommendations for a two-step approach to gender minority measurement; that is, measuring sex assigned at birth and current gender identity. One data source followed best practice recommendations for single item gender minority measurement.[3,14]

Detailed Descriptions of Data Source Methods and Measures

Adult Psychiatric Morbidity Survey: Survey of Mental Health and Wellbeing. The Adult Psychiatric Morbidity Survey[11] was commissioned by England's National Health Service Information Centre for Health and Social Care. This survey was representative of the population residing in households (not communal establishments) in England. Interviews were collected from a population-based sample of ~7500 adults aged 16 years or older. Core topics included in the survey were anxiety, depression, psychosis, substance use disorders, eating disorders, post-traumatic stress disorder, and hyperactivity disorder. Sexual orientation measures changed in 2014 and sexual minority status was measured with three questions concerning identity and behavior. Prior to 2014, sexual orientation was measured with three questions concerning identity, behavior, and attraction. Transgender-inclusive gender identity was not measured.

American Community Survey. An ongoing survey conducted by the U.S. Census Bureau, the American Community Survey (ACS)[12] produced annually updated data for census tracts and block groups formerly surveyed through the decennial census long-form sample. The initial sample was ~3.5million housing unit addresses and group quarters in the United States selected from all counties and county equivalents. The ACS collected data regarding 165,000 respondents' marital and spousal relationships, household characteristics, health insurance, and disabilities. Sexual orientation was measured by partner status; household demographic questions included sex of partner and relationship status. Transgender-inclusive gender identity was not measured.

Australian Longitudinal Study on Women's Health. Initiated in 1996, the Australian Longitudinal Study on Women's Health (ALSWH)[13] was an ongoing population-based study of over 40,000 women in three age-specific cohorts randomly sampled from the Australian Medicare database.

Women from rural and remote areas were sampled at twice the rate of urban women. The study produced health information related to spiritual, behavioral, physical, oral, and sexual health. The ALSWH was linked with Australia's Medicare Benefits data and Pharmaceutical Benefits Scheme. Sexual orientation was measured by sexual identity and partner status. Transgender-inclusive gender identity was not measured.

Behavioral Risk Factor Surveillance System. BRFSS[3,14] assessed information on risk behaviors, preventive health practices, and healthcare utilization for over 400,000 respondents sampled from residents of the 50 states of United States, the District of Columbia, and three U.S. territories by random digit dialing through landlines and cell phones. Inclusion of sexual orientation and transgender-inclusive gender identity questions varied by year and state. Sexual orientation was measured by sexual identity. Transgender-inclusive gender identity was captured by a four-category measure.

California Health Interview Survey. California Health Interview Survey[15] was a biennial, population-based telephone survey of 50,000 Californian residents ≥18 years old. Sexual orientation was measured by sexual identity and 30-day and 12-month sexual behavior. Transgender-inclusive gender identity was not measured.

California Women's Health Survey. Established in 1997, the California Women's Health Survey (CWHS)[16] was an annual random digit dialing telephone survey of ~4000 California women ≥18 years old. CWHS collected information on health indicators and health-related knowledge, behaviors, and attitudes. Sexual orientation was measured by sexual identity and 12-month sexual behavior. Transgender-inclusive gender identity was not measured.

Canadian Community Health Survey. A yearly cross-sectional survey, the Canadian Community Health Survey (CCHS),[17] collected information on health status, healthcare utilization, and health determinants for 65,000 Canadian residents ≥ 12 years old living in private residences. To capture local health data, the survey contained a core module and optional modules that changed every 2 years. Sexual orientation was measured by sexual identity, 12-month sexual behavior, and lifetime sexual behavior. Transgender-inclusive gender identity was not measured.

Colorado Tobacco Attitudes and Behaviors Survey. Colorado Tobacco Attitudes and Behaviors Survey[18] was conducted in 2001, 2005, 2008, 2012, and 2015 and was a population-level, weighted telephone survey of Colorado adults aged 18 and older. The telephone survey covered landlines and cellular telephone numbers. The survey included general demographic characteristics, smoking and cessation history, quit line use, and attitudes about tobacco-related policies. Response rates varied by year. Sexual orientation was assessed by sexual identity. Transgender-inclusive gender identity was not measured.

Current Population Survey. Conducted by the Census Bureau for the Bureau of Labor Statistics, the Current Population Survey[19] provided estimates of employment, earnings, hours of work, and other labor force characteristics for noninstitutionalized, civilian U.S. residents ≥16 years old in ~50,000 households. Sexual orientation was assessed by household roster questions about partner status. Transgender-inclusive gender identity was not measured.

General Social Survey. An annual, multistage area probability study, the General Social Survey,[20] assessed 2000 English- and Spanish-speaking adults ≥18 years old residing in households. Measures included a standard core of demographic, behavioral, and attitudinal questions plus special interest topics. Sexual orientation was measured by sexual identity, 12-month, 5-year, and lifetime sexual behavior. Transgender-inclusive gender identity was not measured.

Growing Up Today Study. Since 1996, the Growing Up Today Study (GUTS)[21] followed a national cohort of 16,700 children of Nurses' Health Study participants aged 9–14 years. In 2004, a second cohort of 10,900 children aged 10–17 years was recruited for GUTS 2. Health topics included alcohol, tobacco, and other drug use; sexual behaviors; body image, weight, activity, and nutrition; health status; and contextual factors. Sexual orientation was measured by lifetime sexual behavior, attraction, and partner status; items varied by survey year. Transgender-inclusive gender identity was captured in the 2010 survey with a single four-category measure.

Healthy Youth Survey. The Healthy Youth Survey[22] was a cross-sectional cohort study collected from Washington State public schools, grades 6–12 (N = 27,752). The Healthy Youth Survey used a cluster sampling design, in which schools were randomly selected and all students at participating schools were invited to complete the surveys. Topics covered in this survey

included health, relationships, behavioral risks such as use of tobacco, alcohol, and other substances, as well as experiences with victimization and bullying. Sexual orientation was assessed with one question about sexual identity. Transgender-inclusive gender identity was not measured.

Kaiser Permanente Member Health Survey. Kaiser Permanente Member Health Survey (KPMHS)[23] was distributed to independent, stratified random samples of ~40,000 adult health plan members ≥ 20 years old in northern California. Conducted every 3 years, the survey assessed self-reported behavioral health risks, health conditions, and health status. Sexual orientation was assessed by a single sexual identity measure in both men's and women's surveys. Transgender-inclusive gender identity was assessed by a single self-identified sex measure in both men's and women's surveys.

Los Angeles County Health Survey. A population-based sample of 7200 adults ≥ 18 years old, the Los Angeles County Health Survey (LACHS),[24] used telephone surveys and interviews to assess health-related needs of Los Angeles county residents. Health indicators, including health knowledge, behaviors, and conditions, and healthcare access were measured. Sexual orientation was assessed by sexual identity and 12-month sexual behavior. Transgender-inclusive gender identity was not measured.

Midlife Development in the United States. Midlife Development in the United States (MIDUS)[25–27] was a longitudinal survey of major biomedical, psychological, and social factors known to contribute to good health, psychological well-being, and social responsibility. MIDUS 1[25] data were collected from 7100 noninstitutionalized U.S. adults aged 25–74 years in 1995–1996. MIDUS 2[26] follow-up data were collected in 2004–2006. MIDUS 3 follow-up data were collected in 2013–2014.[27] MIDUS 1 assessed sexual orientation by sexual identity.[25] MIDUS 2 assessed sexual orientation by sexual identity and partner status.[26] MIDUS 3 assessed sexual orientation by sexual identity and partner status.[27] Transgender-inclusive gender identity was not measured.

Minnesota Student Survey. The Minnesota Student Survey (MSS)[28] was conducted every 3 years with three groups of students in Minnesota public schools: students in regular schools, students in alternative schools, and students in juvenile correctional facilities. The MSS asked questions about student activities, experiences, and behaviors, including tobacco, alcohol, and

drug use, school climate, physical activity, connections with family and school, and health. Sexual orientation was measured by 12-month sexual behavior. Transgender-inclusive gender identity was not measured.

National Adult Tobacco Survey. National Adult Tobacco Survey (NATS)[29] was a random digit-dialed, landline and cellular telephone survey conducted with noninstitutionalized U.S. adults aged 18 and older. The population-based sample was drawn from households in the 50 U.S. states and District of Columbia. The sample included 60,192 interviews and the survey covered topics concerning cigarette and tobacco use patterns across the United States. Sexual orientation was measured by sexual identity. Gender identity was measured with one question. If participants selected ‘‘something else’’ from the sexual orientation question, participants were then asked a follow-up question concerning transgender-inclusive gender identity and sexual identity.

National Alcohol Survey. National Alcohol Survey (NAS)[30] was a representative sample of 7000 U.S. adults ≥ 18 years old. Health measures included information on drinking patterns, alcohol-related health behaviors, and outcomes. Sexual orientation was measured by sexual identity and 5-year sexual behavior. Transgender-inclusive gender identity was not measured.

National College Health Assessment. National College Health Assessment (NCHA) I[31] and NCHA II[32] were nonprobability samples of students attending self-selected universities in the United States. NCHA collected data twice per academic year from randomly selected students ≥ 18 years old to assess alcohol and drug use; sexual health, weight, nutrition, and exercise; mental health; personal safety; and violence. Sexual orientation was measured by sexual identity and 12-month sexual behavior.[31,32] Transgender-inclusive gender identity was assessed in the NCHA I with a single measure that combined sexual identity and gender identity items.[31] The NCHA II measured transgender-inclusive gender identity with a three-category gender identity measure.[32] In fall of 2015, the NCHA IIc expanded transgender-inclusive gender identity measures to describe participants’ gender identities more broadly.[33]

National Comorbidity Survey. A nationally representative survey, the National Comorbidity Survey (NCS),[34–36] measured mental health outcomes of 8000 noninstitutionalized U.S. residents ≥ 18 years old. Baseline data were collected from 1990 to 1992[34] and followed up in the NCS-2 during the period 2001 to 2002.[35] From 2001 to 2003, the NCS-R, a replication

survey of 10,000 new participants, was conducted.[36] Sexual orientation was measured by sexual identity,[36] 5-year sexual behavior,[34,35] and partner status.[34,35] Transgender-inclusive gender identity was not measured.

National Drug Strategy Household Survey. The National Drug Strategy Household Survey (NDSHS)[37] targeted the Australian population age 12 and over. Participants were recruited using a multistage, stratified area, random sample design. The sample included 26,648 respondents, of whom 24,858 responded to sexual orientation questions. The survey covered topics, including, but not limited to, use of alcohol, tobacco, and illicit drugs, victimization arising from use of alcohol or illicit drugs, and demographic characteristics. Sexual orientation was measured by sexual identity. Access to sexual orientation data required additional permissions granted through request and with assurances and protocols to protect respondent confidentiality. Transgender-inclusive gender identity was not measured.

National Epidemiologic Survey on Alcohol and Related Conditions. A cross-sectional national survey, National Epidemiologic Survey on Alcohol and Related Conditions (NESARC),[38] surveyed ~43,000 U.S. residents $\geq$ 18 years old. Health topics included alcohol and drug use, abuse, and dependence and associated comorbidities. Sexual orientation was assessed by sexual identity, lifetime sexual behavior, and attraction. Transgender-inclusive gender identity was not measured.

National Health and Nutrition Examination Survey. National Health and Nutrition Examination Survey (NHANES)[39] was a cross-sectional probability survey that assessed nutrition and health of civilian noninstitutionalized children and adults in the United States. NHANES included socioeconomic, demographic, dietary, and health-related questions, physiological measurements, and laboratory tests. NHANES assessed sexual orientation by sexual identity and 12-month and lifetime sexual behavior. Transgender-inclusive gender identity was not measured.

National Health and Social Life Survey. The National Health and Social Life Survey (NHSLS)[40] assessed a national probability sample of U.S. noninstitutionalized English-speaking individuals 18–59 years old from two middle-sized metropolitan areas. Topics included sexual experiences and social, demographic, and health-related characteristics. Sexual orientation was assessed

by sexual identity, 12-month, 5-year, and lifetime sexual behavior, attraction, and partner status. Transgender-inclusive gender identity was not measured.

National Health Interview Survey. Initiated in 1957, the National Health Interview Survey (NHIS)[41] surveyed ~87,500 civilian noninstitutionalized children and adults in the United States in over 35,000 U.S. households. The Family Core Questionnaire assessed demographics, socioeconomic status, healthcare coverage, health status, and healthcare utilization of adult respondents. Historically, sexual orientation was assessed by partner status in the household roster. In 2013, a sexual identity measure was added. Transgender-inclusive gender identity was not measured.

National Intimate Partner and Sexual Violence Survey. National Intimate Partner and Sexual Violence Survey (NISVS)[42] was an ongoing nationally representative survey that assessed the experiences of sexual violence, stalking, and intimate partner violence among adult men and women, aged 18 years and older, in the United States. Sexual orientation was measured by sexual identity and lifetime sexual behavior. Transgender-inclusive gender identity was measured not with a distinct question, but as a possible response to the sexual identity question.

National Latino and Asian American Study. National Latino and Asian American Study (NLAAS)[43] was a complex, multistage, household probability survey of noninstitutionalized U.S. Latino and Asian American adults aged 18 and older. Participants (N= 4649) were administered a face-to-face interview concerning mental health and psychiatric disorders based on the World Mental Health Survey Initiative. Sexual orientation was measured by sexual identity and 12-month sexual behavior. Transgender-inclusive gender identity was not measured.

National Longitudinal Study of Adolescent to Adult Health. A longitudinal cohort study, the National Longitudinal Study of Adolescent to Adult Health (Add Health),[44] followed a nationally representative sample (N = 14,400) of U.S. adolescents in grades 7 through 12 in the 1994 to 1995 school year. Four waves of data collection were completed. Sexual orientation was assessed by sexual identity, 12-month sexual behavior, lifetime sexual behavior, attraction, and partner status. Transgender-inclusive gender identity was not measured.

National Research Consortium of Counseling Centers in Higher Education. This data source surveyed a stratified random sample of 108,536 students from 70 U.S. institutions of higher education. Surveys were administered through a Web-based questionnaire to undergraduate and graduate students. The survey assessed topics including suicidal ideation and severity, psychological distress, coping, and other mental health concerns. Sexual orientation was measured by sexual identity. Transgender-inclusive gender identity was measured with a single gender identity question.[45]

National Social Life, Health, and Aging Project. A population-based, household probability sample, the National Social Life, Health, and Aging Project (NSHAP),[46] assessed community-residing U.S. adults aged 57–85 years. Topics included social networks, social and cultural activity, physical and mental health, and sexual history. Sexual orientation was measured using 5-year sexual behavior and a household roster to assess partner status. Transgender-inclusive gender identity was not measured.

National Survey of Family Growth. National Survey of Family Growth[47] interviewed over 12,000 noninstitutionalized U.S. women (Cycles I-VI) and men (beginning in Cycle VI), 15–44 years old. General topics included family life, marriage and divorce, pregnancy, infertility, use of contraception, and health. Sexual orientation was assessed by sexual identity, 12-month sexual behavior, lifetime sexual behavior, attraction, and partner status. Transgender-inclusive gender identity was not measured.

National Survey on Drug Use and Health. The National Survey on Drug Use and Health (NSDUH)[4] began in 1971 and was conducted annually with a random sample of 70,000 non-institutionalized, U.S. residents $\geq$ 12 years old. Topics included trends in alcohol, tobacco, and illicit drug use; demographics; mental health; and related topics. Historically, NSDUH assessed sexual orientation with a single sexual behavior measure. Beginning in 2015, measures of sexual identity and attraction were added. Transgender-inclusive gender identity was not measured.

National Survey of Sexual Attitudes and Lifestyles. National Survey of Sexual Attitudes and Lifestyles (Natsal)[48–50] began in 1990 as the first nationally representative survey of sexual behavior and attitudes in Britain. The goal of this program was to describe patterns of sexual behavior in Britain, provide data for HIV/AIDS projections, assess changes in sexual attitudes

and behavior, and determine the prevalence of sexually transmitted infections. Sexual orientation was measured with questions about sexual identity and lifetime sexual behavior. Transgender-inclusive gender identity was not measured.

National Violence Against Women Survey. The National Violence Against Women Survey (NVAW)[51] was a nationally representative probability sample of 8000 women and 8000 men aged 18 years and older. The survey assessed violence against women, including victimization in childhood and subsequent victimization, physical assault, forcible rape and stalking, injury rates, and use of medical services as a result of violence against women. NVAW measured sexual orientation by partner status. Transgender-inclusive gender identity was not measured.

New York City Community Health Survey. The New York City Community Health Survey (NYC CHS)[52] was an annual survey that sampled noninstitutionalized adults aged 18 years and older who lived in NYC and had either a landline or cellular telephone. Topics included the health of New Yorkers including chronic disease and behavioral risk factors. Sexual orientation was measured by sexual identity and 12-month sexual behavior. Transgender-inclusive gender identity was not measured.

New York City Health and Nutrition Examination Survey. New York City Health and Nutrition Examination Survey (NYC HANES)[53] was a population-based cross-sectional survey of the NYC noninstitutionalized adult population 20 years and older and was modeled after the NHANES.61 Respondents provided an in-depth health interview, physical examination, and laboratory tests. Sexual orientation was assessed with sexual identity and lifetime sexual behavior questions. Transgender-inclusive gender identity was not measured.

Nurses' Health Study II. Beginning in 1989, the Nurses' Health Study II (NHS II)[54] was a prospective survey mailed every 2 years to 116,700 female nurses 25–42 years old at baseline in California, Connecticut, Indiana, Iowa, Kentucky, Massachusetts, Michigan, Missouri, New York, North Carolina, Ohio, Pennsylvania, South Carolina, and Texas. NHS II focused on oral contraceptives, diet, and lifestyle risk. Sexual orientation was assessed with a sexual identity measure. Transgender-inclusive gender identity was not measured.

Personality & Total Health Through Life. A 20-year longitudinal study, Personality & Total Health,[55] surveyed over 7000 community residents randomly selected from the electoral rolls of

Canberra and Queanbeyan in Australia. Each study wave consisted of (at baseline) three cohorts: 20–24 years old, 40–44 years old, and 60–64 years old. Health topics included depression and anxiety, alcohol and drug addiction, and cognitive functioning and dementia. Each survey measured sexual orientation by sexual identity. Transgender-inclusive gender identity was not measured.

Project on Human Development in Chicago Neighborhoods. Project on Human Development in Chicago Neighborhoods (PHDCN)[56] was a multilevel, prospective cohort study of 6226 adolescents and children, their caregivers, and neighborhoods randomly sampled from neighborhood clusters in Chicago, Illinois. The full project involved households with children in one of seven age groups (in utero, 3, 6, 9, 12, 15, and 18 years old). PHDCN used a comprehensive in-person interview and self-report questionnaire to assess sexual orientation, sexual risk indicators, and sexual abuse victimization. Sexual orientation was assessed by attraction. Transgender-inclusive gender identity was not measured.

U.S. Census. Conducted by the Census Bureau[57] for the Bureau of Labor Statistics, the census provided decennial estimates of disability, birth rates, employment and economic indicators, and household characteristics for persons dwelling in U.S. households, including citizens, noncitizen legal residents, noncitizen long-term visitors, and undocumented immigrants. Sexual orientation was assessed by household roster questions about partner status. Transgender-inclusive gender identity was not measured.

Women's Health Initiative. A longitudinal, randomized, controlled comparison trial and observational study, the Women's Health Initiative (WHI),[58] assessed 161,800 postmenopausal women, aged 50–79 years beginning in 1993. In 2005, the WHI Extension Study (2005–2010, 2010–2015) continued follow-up of all consenting participants. Topics included demographic, psychosocial factors, and physical and mental health issues, including cancer and cardiovascular disease prevention. Sexual orientation was measured by sexual behavior after age 45 and lifetime sexual behavior. Transgender-inclusive gender identity was not measured.

Youth2000. The Youth2000[59] survey was a cross-sectional self-administered questionnaire concerning the health and well-being of secondary school students conducted in 2001, 2007, and 2012. It included a representative sample of secondary students in New Zealand. Surveys were completed anonymously by students enrolled at a secondary school using computer-

assisted self-interviewing technology. Sexual orientation was measured by attraction. In 2012, transgender-inclusive gender identity was measured with a single gender identity question.

Youth Risk Behavior Surveillance System. A national, state, and regional system of school-based probability surveys, the Youth Risk Behavior Surveillance System (YRBSS),[60] assessed U.S. public and private school students aged 12–18 years. Inclusion of sexual orientation questions varied by year and state until 2015 when the national YRBSS measured sexual orientation by identity and lifetime sexual behavior. Transgender-inclusive gender identity was not measured.

Discussion

With this work, we provided a review of data sources that included SGM measures. We have also identified the limitations in best practice measurement of SGM populations in these data sources as compared to best practice recommendations. Our findings point to opportunities to improve largescale collection of SGM data. This is especially important in light of the 2011 IOM report, which calls for standards to revise SGM measures across health surveillance resources to improve measurement precision with the intent to meaningfully compare data across surveys and achieve nationally representative data sources.[1]

This article's purpose rested on the philosophical tenet that public health data sources including sexual orientation and transgender-inclusive gender identity measures should be readily accessible, yet these data can be difficult to locate and no single scholarly resource documented their location. Using published recommendations for measurement of sexual orientation[6] and transgender-inclusive gender identity[7] as inclusion criteria, we filled this gap by identifying large-scale, publicly available, health surveillance resources that included sexual orientation or transgender-inclusive gender identity measures; increasing their accessibility to maximize value for SGM health research. Furthermore, by comparing data sources with these recommendations, we identified how available health surveillance data sources differed from each other and best practice.

Limitations in SGM Health Surveillance

SGM measurement. A growing number of health surveillance data sources measured sexual orientation or transgender-inclusive gender identity, as evidenced by the data sources identified

and summarized herein. Very few of the data sources measured sexual orientation and transgender-inclusive gender identity consistently across data sources, within data sources across time, or according to recommended guidelines.

Just over half of the 43 data sources assessed sexual minority status with two or more dimensions of sexual orientation, with most measuring sexual identity and behavior at minimum.[4,11,15–17,20,24,30–36,38–40,42–44,47–50,52,53,60] Yet, only 14% followed best practice recommendations to measure sexual identity, sexual behavior, and attraction to assess sexual orientation.[4,11,38,40,44,47]

Notably, 40% of data sources measured a single dimension of sexual orientation.[3,13,14,18,22,23,25–29,37,41,45,46,54–56,58,59] This is in direct contrast to published recommendations to measure multiple dimensions of sexual orientation.[6] Single-item sexual orientation measures limit what can be known about sexual orientation and health because sexual identity, behavior, and attraction are not always concordant and do not all confer the same type and degree of health risk. Therefore, it is important that multiple sexual orientation measures be used to capture sexual minority persons accurately and understand population-level risk and health.[6]

Data sources also varied in the type of measure used to assess sexual behavior as a dimension of sexual orientation; specifically, sexual behavior measurement included same-sex sexual behavior in the past 30 days, 12 months, 5 years, and lifetime. Discordance in measurement across health surveillance resources limits our ability to conduct meaningful comparisons across data and surveys. Public health surveillance must employ standard measures of sexual orientation dimensions across data sources to reliably assess and quantify health disparities experienced by sexual minorities.[1,6]

Only 19% of data sources measured transgender-inclusive gender identity and most sources included only a single transgender-inclusive gender identity measure.[3,14,21,23,29,42,45,59] Single-item measurement is problematic because some transgender individuals identify their gender as male or female and not as transgender,[62] thereby occluding the presence and experiences of these transgender individuals. This significantly limits what can be known about health, risks, and disparities and curtails the development of optimal disparity-reducing interventions for the diverse group of individuals who identify on the spectrum of transgender identities.

Rigorous, population-based health surveillance should measure transgender-inclusive gender identity through a two-step approach with items that capture sex assigned at birth and current gender identity.[7,62] No data sources identified in this search utilized this two-step approach to capture gender minority identity. To fully capture the diversity of the transgender community, experts also suggest expanding measurement of transgender-inclusive gender identity questions and response options to include genderqueer/gender nonconforming and other identities.[7] Only two data sources included genderqueer or gender nonconforming as response items.[3,14,33]

Age. There appears to be a difference in how sexual orientation is measured depending on the age of participants that may be problematic for older adults. This review identified 15 data sources that included sexual orientation measures for youth below the age of 18.[4,11,17,21,22,28,37,39,41,44,47–50,56,59,60] Of these data sources, 27% (N= 4) asked questions concerning all three aspects of sexual orientation.[4,11,44,47] Comparatively, of the 28 data sources that included sexual orientation measures only for respondents aged 18 or older,[3,12–16,18–20,23–27,29–36,38,40,42,43,45,46,51–55,57,58] only 7% (N= 2) asked questions concerning all three aspects of sexual orientaton.[38,40] Variation in measurement by age is problematic because risk for health and health-related problems differs depending on how sexual orientation is measured. By limiting the range of questions concerning sexual orientation to younger ages only, what can be known about health and health risk as it pertains to behavior, attraction, and identity among adults is systematically limited. Similarly, in some data sources, participants over the age of 59 are asked only specific sexual orientation questions. For example, NHANES includes sexual behavior questions for adults up to age 69; however, the survey includes sexual identity questions only for adults aged 59 and younger.[39] We believe this is problematic because it is probable that one's sexual orientation remains salient after age 59, some or all aspects of sexual orientation are not static and may change over time, and that the multiple aspects of sexual orientation remain relevant to health after age 59.[1]

Data Linkages. A strength of health surveillance programs is the capacity to link health surveillance data with healthcare administrative data to better investigate complex health-related issues. In the United States, the National Center for Health Statistics has linked both the NHIS and the NHANES to specific administrative datasets, including the National Death Index (NDI) as well as Centers for Medicare and Medicaid Services (CMS), Social Security Administration (SSA), and U.S. Housing and Urban Development (HUD) administrative files.[63]

However, information on SGM populations that can be drawn through these data linkages is extremely limited.

Specifically, as NHIS only began collecting information on sexual identity as part of the 2013 survey, no additional data linkages are yet available.[63] NHANES, which began collecting data on sexual identity in 2001 and same-sex sexual behavior in 1999, offers more opportunity for analysis of administrative datasets: NDI, CMS, SSA, and HUD data are currently available for 1994–2004 surveys, and NDI data are also available from 2005 to 2010.[63] However, sexual orientation questions asked of NHANES participants are age restricted. Sexual identity is asked of participants 18–59 years of age and sexual behavior is asked of participants 18–69 years of age.[39] Yet, sexual orientation remains salient and could possibly change after ages 59 and 69.[1,64,65] This limits the utility of linked data sources because little information on older sexual minority adults (age 65+) can be drawn from linked data sources.

In addition, while evidence suggests that sexual minorities are more likely to engage in risky health behaviors (e.g., tobacco use and heavy alcohol use) and experience chronic disease,[1] we are less able to examine connections between these variables and mortality due to age-restricted sampling. This problem is not restricted to the United States; the CCHS,[17] while linked with datasets measuring mortality, hospital admissions, and finances,[66] measures sexual identity only for respondents of age 18–59 and sexual behavior for respondents of age 18–49. Such restrictions compromise our capacity to understand sexual minority health.

Only KPMHS measures transgender-inclusive gender identity and offers linked information to administrative and clinical data, thus offering an opportunity to explore healthcare utilization among this group.[23,67] However, similar to NHANES[39] and CCHS,[17] the KPMHS is age-restricted to respondents 20–60 years old and thus limits our understanding of aging and health among SGMs.[23] No national data sources exist that include transgender-inclusive gender identity measures and are linked with administrative or clinical data. These omissions severely limit our capacity to understand gender minority health.

<u>Sampling</u>. The reviewed data sources also suffered from another limitation. None of the reviewed data sources oversampled for SGM populations. This is problematic because SGMs exist in small proportion relative to the general population. Under optimal population-based sampling strategies, very few (~3%–5%) samples will include SGM persons. These very small

sample sizes significantly restrict empirical investigation of health, health disparities, and health needs among these groups. This problem is similar to that of underrepresentation of racial/ethnic minority persons in population-based data sources, which has previously been resolved with oversampling strategies. Oversampling SGM groups could decrease underrepresentation in health surveillance data sources and ensure reliable estimates of population demographics and health.

Opportunities for Future SGM Health Surveillance

Despite the limitations of the data sources reviewed and summarized herein, this article complements existing listings of sexual minority-inclusive data sources[5] in two ways. First, it provides scholarly documentation and review of publicly available, large-scale, health surveillance data sources that include measures of transgender-inclusive gender identity as well as sources that include both sexual orientation and transgender-inclusive gender identity measures. Second, it provides meaningful comparison of SGM measures included in health surveillance with the published recommended best practices.

Although the measures included in public health surveillance are constantly changing, and some new data sources may become publicly accessible in the future (i.e., The PRIDE Study) and others may begin to include SGM measures (i.e., Health Information National Trends Survey), this detailed review of the publicly available, large-scale health surveillance resources that measure SGMs provides a peer-reviewed scholarly reference from which researchers can build upon and evaluate limitations, identify opportunities for future growth, and chart progress over time in SGM data collection.

<u>SGM Measurement</u>. Our results suggest that current public health surveillance resources are greatly limited in their measurement of sexual orientation and transgender-inclusive gender identity. Too few large-scale, publicly available, rigorously sampled data sources measure SGMs. Those that do include SGM measures do so inconsistently within and across data sources and in relation to best practice recommendations. In addition to increasing the number of SGM-inclusive data sources, we recommend modifications to SGM measures currently included across public health surveillance, cohort, and observational data sources to close the gap between current measurement and best practice recommendations.

To improve sexual orientation measurement, we encourage researchers to include, at minimum, two dimensions of sexual orientation: sexual identity and sexual behavior. This practice standard is being met by a majority of largescale, public health surveillance resources and can be built upon to achieve consistency across data sources. In addition, while study aims dictate survey measures to ensure precision across data sources, sexual behavior measures should include lifetime same-sex sexual behavior and, ideally, two time periods (i.e., in addition, a 5-year or 12-month item dependent on study aims). To capture gender minority identity, we encourage researchers to, at minimum, add a single-item transgender identity question to surveys so that we may begin to gather national representative data for this group.

For all SGM measures, we encourage health surveillance administrators and researchers to use language outlined in best practices set forth by the Williams Institute.[6,7] These changes could improve investigations of SGM health and the ability to identify disparities by allowing for comparisons across data sources. Such comparisons could result in new or extended findings and increase the potential for developing health-promoting and disparity-eliminating solutions for SGM groups.

Age. The substantial gaps in SGM measurement of older adults among existing health surveillance data sources greatly limit our understanding of this growing and vulnerable group. An estimated 2.4 million LGBT adults, age 60 and older, currently reside in the United States, and that number is expected to grow to over 5 million by 2030.[68]

Current evidence suggests that SGM older adults are at risk for experiencing victimization, higher alcohol and tobacco use, poor mental and physical health, and disability.[69,70] However, existing studies of SGM older adults have mostly used community-based nonprobability sampling and small sample sizes because population-based health surveillance data sources are largely unavailable. To date, no studies have examined response rates among older adults for transgender-inclusive gender identity measures. Considering this evidence, and given the rising number of SGM older adults, health surveillance surveys must include SGM measures for older adults. Only then can researchers, policy makers, and practitioners best develop targeted cost-effective solutions for addressing the health needs of this vulnerable group.

Data Sources. Our review highlights critical gaps in SGM-inclusive data sources that must be filled to advance comprehensive health surveillance for this population. A significant concern is

that no accurate census count of SGM people exists. Without direct questions about sexual orientation and transgender-inclusive gender identity, national estimates of SGM populations are aggregated from multiple surveys, thus creating variability in percentage estimates for these groups. Without SGM census counts, we are unable to clearly articulate who SGM people are and what needs they have. Subgroups of SGM people are significantly underrepresented (e.g., racial/ethnic minorities, older adults, and immigrants) and this severely limits our understanding of health and health disparities within the SGM community. In addition, without federal SGM census data, we cannot determine correct statistical weighting for SGMs represented in national probability surveys. This gap may cause researchers using existing weighting to make inaccurate population-based estimates of SGM health-related outcomes. Using unweighted data is also problematic because it may limit the utility of existing probability sampling health surveillance to non-generalizable estimates of SGM sample characteristics.

With these limitations in mind, we strongly advocate for including SGM measures beyond those capturing partner status in the federal census as a priority for advancing future SGM health research. Several data sources are notably absent from our review. For example, despite the disproportionate prevalence of cancer risk factors among SGMs,[1] cancer incidence and mortality are largely unmonitored for this group. National cancer surveillance data sources, specifically SEER and the American Cancer Society's Cancer Prevention Studies (CPS), have not included SGM measures historically.[2] The CPS-3, which began recruitment in 2013, now includes a sexual orientation measure;[71] however, these data are not publicly available. Future SGM-inclusive cancer surveillance is essential for understanding the cancer burden among SGMs and developing disparity-reducing prevention and treatment programs for this population.

Public Dissemination. As previously discussed, this article provides a systematic review of publicly available, large-scale health surveillance data sources that measure SGMs. Given the IOM recommendation to expand SGM health surveillance,[1] it is imperative that researchers, practitioners, and policy makers continue to monitor and track improvements in SGM measurement within existing and newly developed health surveillance programs.

As a central body tasked with leveraging resources to support SGM health research, the National Institutes of Health's Sexual and Gender Minority Research Office (SGMRO) is uniquely positioned to track and disseminate information on SGM-inclusive health surveillance. To this end, we suggest that the SGMRO conduct ongoing review and publication of SGM-

inclusive health surveillance data sources, including specific SGM measures, as well as a summary of the state of SGM-inclusive health surveillance. These efforts may be leveraged to track progress in SGM measurement, identify gaps in SGM health surveillance, and set national priorities for SGM health research.

Conclusion

With this work, we intended to contribute to the collective, peer-reviewed, scholarly knowledge base about data sources that include SGM measures and can be used to inform research about health risks and disparities among SGM populations. Future recommendations are for increased SGM-inclusive data sources, more rigorous measurement of sexual orientation and transgender-inclusive gender identity concordant with best practice recommendations, and oversampling of SGM populations. Only then can needs be identified, solutions developed, tested, and disseminated toward the overarching aim: to develop programs and policies that best serve the unique health needs of and eliminate health disparities experienced by lesbian, gay, bisexual, and transgender communities.

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Appendix. Figures and Tables

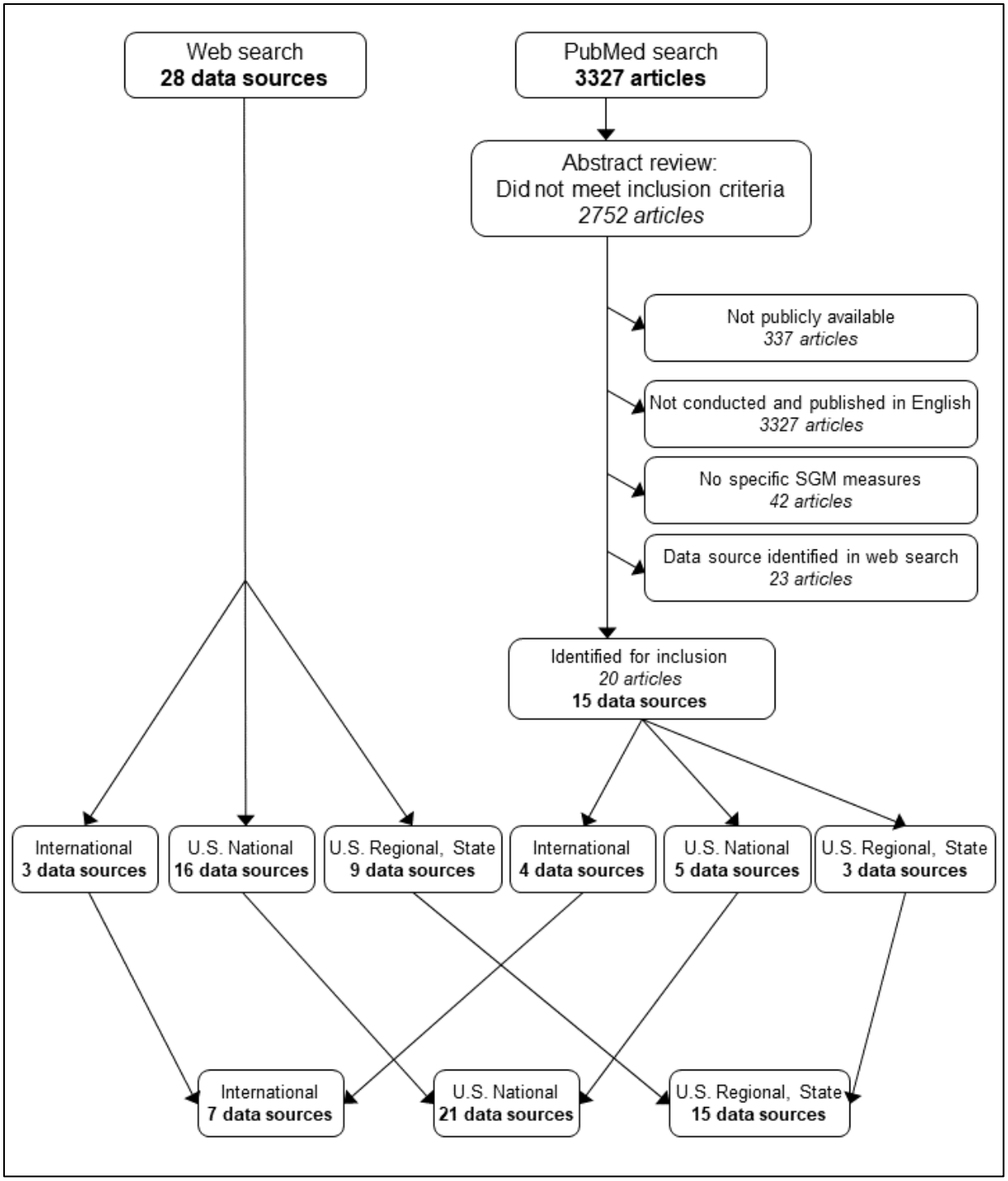

Figure 2.1 Exclusion cascade for PubMed and targeted web search

Table 2.1 Sexual minority-inclusive health surveillance data sources

Name/ Study Website	Sampling Design		Study design	Years	Question Type							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
Adult Psychiatric Morbidity Survey: Survey of Mental Health and Wellbeing, England11 http://content.digital.nhs.uk/article/3739/National-Study-of-Health-and-Wellbeing			Population; non-institutionalized British residents; Age ≥16 Size: Varies 2014: 7,500	2000, 2007, 2014								2014: Which of the following options best describes how you think of yourself? Heterosexual or Straight, Gay or Lesbian, Bisexual, Other Altogether in the last 5 years, how many same sex partners have you had sex with? And altogether, in the last year, how many same sex partners have you had sexual intercourse with? 2007: Which statement best describes your sexual orientation? This means sexual feelings, whether or not you have had any sexual partners. Entirely heterosexual (attracted to persons of the opposite sex); Mostly heterosexual, some homosexual feelings; Bisexual (equally attracted to men and women); Mostly homosexual, some heterosexual feelings; Entirely homosexual (attracted to persons of the same sex) Have your sexual partners been…? only opposite sex, mainly opposite sex but some same sex partners, mainly same sex but some opposite sex partners, only same sex, I have not had a sexual partner Please choose the answer below that best describes how you think of yourself: completely heterosexual, mainly heterosexual, bisexual, mainly gay or lesbian, completely gay or lesbian	PI: National Centre for Social Research, and the Department of Health Sciences, University of Leicester. Email: enquiries@nhsdigital.nhs.uk Phone: +44 (0) 0300 303 5678 Data Access: https://discover.ukdataservice.ac.uk/series/?sn=2000044

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Question Type							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
American Community Survey[12] census.gov/acs			Population: non-institutionalized, U.S. residents; Age: all ages Size: Varies	Annually 2000-present								How is this person [Person 2] related to Person 1? Husband or wife, Unmarried Partner What is Person 2's sex? Male Female	PI: United States Department of Commerce, United States Census Bureau Phone: 1-800-923-8282 Data access: http://www.census.gov/programs-surveys/acs/
Australian Longitudinal Study on Women's Health[13] alswh.org.au			Population: female Australian Medicare recipients Age 18-23, 45-50, 70-75 in 1996 Size: 41,600	1996-present Longitudinal								*1946-1951 cohort-specific questions:* What is your present marital status? (Mark one only) Married (registered), De facto relationship (opposite sex), De facto relationship (same sex), Separated, Divorced, Widowed, Never married (2013, 2010, 2007) *1973-1978 cohort-specific questions:* Which of these most closely describes your sexual orientation? (Mark one only) I am exclusively heterosexual, I am mainly heterosexual, I am bisexual, I am mainly homosexual (lesbian), I am exclusively homosexual (lesbian), I don't know, I don't want to answer (2014, 2012) What is your present marital status? (Mark one only) Never married, Married, De facto (opposite sex), De facto (same sex), Separated, Divorced, Widowed (2015, 2012, 2009) What are your living arrangements? (Mark all that apply) I live alone, I live with one or both parents, I live with other adults, I live with my male partner, I live with my female partner (2014)	Email: a.dobson@sph.uq.edu.au Data access: requires application and study team review More information: http://alswh.org.au/how-to-access-the-data/alswh-data

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Question Type							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
Australian Longitudinal Study on Women's Health[13] (continued)												*1989-1995 cohort-specific questions:* Which of these most closely describes your sexual orientation? (Mark one only) I am exclusively heterosexual, I am mainly heterosexual, I am bisexual, I am mainly homosexual (lesbian), I am exclusively homosexual (lesbian), I don't know, I don't want to answer What are your living arrangements? (Mark all that apply) I live alone, I live with one or both parents, I live with other adults, I live with my male partner, I live with my female partner (2015)	
Behavioral Risk Factor Surveillance System[3,14] cdc.gov/brfss/			Population: non-institutionalized U.S. residents Age $\geq$ 18 years Size: Varies	Annual								We ask this question in order to better understand the health and health care needs of people with different sexual orientations. Do you consider yourself to be: Straight, Lesbian or Gay, Bisexual, Other, Don't know/Not Sure	PI: Centers for Disease Control and Prevention Behavioral Survey Branch Data access: contact state-by-state project officers (https://www.cdc.gov/brfss/state_info/coordinators.htm) More information: See BRFSS state-added question database (https://www.cdc.gov/brfss/questionnaires/index.htm)
California Health Interview Survey[15] chis.ucla.edu			Population: California residents; Age $\geq$ 18 years Size: 50,000	Biennially								Do you think of yourself as straight or heterosexual, gay/lesbian or homosexual, or bisexual? Is that partner [(if sexually active]) male or female? [Referring to past 30 days]	PI: UCLA Center for Health Policy Research Email: chis@ucla.edu Phone: 866-275-2447 Data access: sexual minority data are restricted; require application and payment of min. 1,000 data processing/analysis fee

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
California Health Interview Survey[15] (continued)												In the past 12 months, have your sexual partners been male, female, or both male and female?	More information: chis.ucla.edu/main/DAC/default.asp
California Women's Health Survey[16] http://www.dhcs.ca.gov/dataandstats/Pages/CWHS.aspx			Population: California adult women living in households with telephones Age ≥ 18 years Size: ~4,000	Annually since 1997								Which of the following best describes you? Would you say… Heterosexual (straight), Gay or Lesbian, Bisexual, Not sure, Don't know Which response best describes whom you have had sex with in the past 12 months? Would you say… Sex only with a woman (or with women), Sex only with a man (or with men), Sex with both men and women, Did not have sex, Don't know	Contact: Julia C. Tomassilli, PhD Email: julia.tomassilli@csus.edu Phone: 916-278-2081 More information: http://www.dhcs.ca.gov/dataandstats/reports/Documents/OWHReports/SurveysandDocumentation/CWHS.2012.Documentation.pdf Note: Refer to technical documentation before requesting data
Canadian Community Health Survey[17] statcan.gc.ca/imdb-bmdi/3226-eng.htm			Population: non-institutionalized, Canadian residents Age ≥ 12 years Size: 65,000	Biennially 1991-2007 Annually 2008-Present								Do you consider yourself to be…? Heterosexual (sexual relations with people of the opposite sex), Homosexual, that is lesbian or gay (sexual relations with people of your own sex), Bisexual (sexual relations with people of both sexes) In the past 12 months, have you had sex with a male? In the past 12 months, have you had sex with a female? During your lifetime, have you had sex with…? Males only, Females only, Both males and females	PI: Statistics Canada Email: hd-ds@statcan.gc.ca Phone: 613-951-1746 Data access: requires application and fulfillment of eligibility criteria, data must be analyzed at Research Data Centers More information: statcan.gc.ca/rdc-cdr/

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
Colorado Tobacco Attitudes and Behaviors Survey[18] http://www.ucdenver.edu/academics/colleges/PublicHealth/community/CEPEG/TABS/Pages/TABS.aspx			Population: English or Spanish speaking Colorado residents Household sampling based on landline or cellphone Age ≥ 18 Size: 12,000-18,000	2001, 2005, 2008, 2012, 2015								Do you consider yourself to be: Heterosexual, that is, straight; Homosexual, that is gay or lesbian; Bisexual, or something else?	Contact: Colorado School of Public Health Email: colorado.sph@ucdenver.edu Phone: 303-714-4585 Data access: http://www.ucdenver.edu/academics/colleges/PublicHealth/community/CEPEG/TABS/Surveys/Pages/default.aspx
Current Population Survey[19] census.gov/cps/			Population: civilian non-institutionalized U.S. residents Age ≥ 16 years Size: 50,000	Monthly								How is [Person 2] related to you? Opposite-sex spouse (Husband/Wife), Opposite-sex Unmarried Partner, Same-sex Spouse (Husband/Wife), Same-sex Unmarried Partner	PI: United States Department of Commerce, United States Census Bureau Phone: 1-800-923-8282 Data access: http://www.census.gov/programs-surveys/cps/data-detail.html
General Social Survey[20] gss.norc.org/			Population: non-institutionalized U.S. residents Age ≥ 18 years Size: 2,000	Annually until 1994 Biennially since 1994								Which of the following best describes you? Gay, lesbian, or homosexual; Bisexual; Heterosexual or Straight; Don't Know Have your sex partners in the last 12 months been… Exclusively male, Both male and female, Exclusively female, Don't know Have your sex partners in the last 5 years been… Exclusively male, Both male and female, Exclusively female, Don't know	PI: Tom W. Smith Email: GSS@norc.org Phone: 733-256-6288 Data access: Available for download at http://gss.norc.org/Get-The-Data or through https://gssdataexplorer.norc.org

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
General Social Survey[20] (continued)												Now, thinking about the time since your 18th birthday (again, including the recent past that you have already told us about) how many female partners have you ever had sex with? Again thinking about the time since your 18th birthday (again, including the recent past that you have already told us about) how many male partners have you ever had sex with?	
Growing Up Today Study[21] gutsweb.org/			Population: Children of Nurses' Health Study participants Age: 9-14 in 1996 and 10-17 in 2004 Size: GUTS - 16,700 GUTS2 - 10,900	Annually since 1996 Longitudinal								During your life, the person(s) with whom you have had sexual contact (however your define it) is (are): I have not had sexual contact with anyone, Female(s), Males(s), Female(s) and Male(s) Which of the following best describes your feelings? Completely heterosexual (attracted to persons of the opposite sex), Mostly heterosexual, Bisexual (equally attracted to men and women), Mostly homosexual, Completely homosexual (gay/lesbian, attracted to persons of the same sex), Not sure Is your partner in your current relationship: Male, Female	Contact: Xenia Kumph, Project Manager Email: gutsadmin@channing.harvard.edu Data access: Investigators who are interested in using GUTS data or surveys should email the Project Manager.
Healthy Youth Survey[22] http://www.doh.wa.gov/DataandStatisticalReports/DataSystems/HealthyYouthSurvey			Population: Students from schools randomly sampled at the state level Age: grades 6, 8, 10, and 12 Size: Varies	2002, 2004, 2006, 2008, 2010, 2012, 2014								Which of the following best describes you? Heterosexual (straight), Gay or lesbian, Bisexual, Not sure	Contact: Jennifer Sabel Email: Jennifer.Sabel@doh.wa.gov Phone: 360-236-4248 Data Request: http://www.doh.wa.gov/DataandStatisticalReports/DataSystems/HealthyYouthSurvey

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
Kaiser Permanente Member Health Survey[23] dor.kaiser.org/external/DORExternal/mhs/index.aspx			Population: northern California Kaiser health plan members; Age ≥ 20 years Size: 42,000	1993-ongoing, every 3 years								Are you bisexual or [lesbian/gay]? No; yes, bisexual; yes, [lesbian/gay].	Nancy P. Gordon, ScD, Study Director, Research Investigator, Division of Research Phone: 510-891-3587 Email: nancy.gordon@kp.org dor.kaiser.org/external/Nancy_Gordon/
Los Angeles County Health Survey[24] lapublichealth.org/ha/hasurveyintro.htm			Population: Los Angeles county residents Age ≥ 18 years Size: 7,200	1997 1999-2000, 2002-2003, 2005, 2007, 2011								Now I'll read a list of terms people sometimes use to describe themselves. As I read the list, please stop me when I get to the term that best describes how you think of yourself. Heterosexual/Straight, Homosexual/gay/Lesbian, Bisexual, Don't Know Over the PAST 12 MONTHS, with how many [women/men] have you had sex?	PI: Los Angeles County Department of Public Health Phone: 213-240-7785 Data access: requires submission of a proposal and documentation of data security. More information on data access: lapublichealth.org/ha/HA_DATA.htm

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
Midlife Development in the United States[25-27] Midus.wisc.edu			Population: non-institutionalized, English-speaking U.S. adults Age 25-74 Size: 7,100	Wave 1: 1995-1996 Wave 2: 2004-2006 Wave 3: 2013-2014 Longitudinal								MIDUS 1: How would you describe your sexual orientation? Would you say you are heterosexual (sexually attracted only to the opposite sex), homosexual (sexually attracted only to your own sex), or bisexual (sexually attracted to both men and women)? MIDUS 2: How would you describe your sexual orientation? Heterosexual, homosexual, bisexual MIDUS 2: Is [KHNAME] a male or a female? Male, Female, Don't Know/Not Sure MIDUS 2: How is [KHNAME] related to you? Husband or wife, lover/partner, same-sex lover/partner MIDUS 3: Is [KHNAME] a male or a female? Male, Female, Don't Know/Not Sure MIDUS 3: How is [KHNAME] related to you? Husband or wife, lover/partner, same-sex lover/partner	PI: Carol Ryff, PhD Phone: 608-262-2056 Data and documentation available for download: dx.doi.org/10.3886/ICPSR04652
Minnesota Student Survey[28] http://www.health.state.mn.us/divs/chs/mss/			Population: students in public, alternative schools, area learning centers, and juvenile correction Age: grades 6, 9 and 12 Size: Varies 2013: 165,000	Conducted every three years; 1992-2013								During the last 12-months, with how many different male/female partners have you had intercourse? (dichotomized to 'had sex with someone of the same sex or had heterosexual sex)	Contact: Ann Kinney Email: ann.kinney@state.mn.us Phone: 651-201-5946 Data Access: email to request data use and agreement forms

Table 2.1 continued

Name/ Study Website	Sampling design				Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability	Study design	Years	Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
National Adult Tobacco Survey[29] http://www.cdc.gov/tobacco/data_statistics/surveys/nats/			Population: U.S. national stratified sample based on landline and cell phone of non-institutionalized adults Age ≥18 years Size: Varies	2009-2010, 2012-2013								Do you think of yourself as …..? For men: Gay; Straight, that is, not gay; Bisexual; Something Else For women: Lesbian or gay; Straight, that is, not lesbian or gay; Bisexual; Something Else	PI: Centers for Disease Control and Prevention Phone: 800-CDC-INFO Data Access: http://www.cdc.gov/tobacco/data_statistics/surveys/nats/
National Alcohol Survey[30] arg.org/center/national-alcohol-surveys/			Population: U.S. residents Age ≥ 18 years Size: 7,000	2005, every 5 years								Which of the following statements best describes your sexual orientation? Heterosexual, that is, 'straight,' or prefer to have sex with people of the opposite sex; Bisexual, that is, prefer to have sex with people of either sex; or Homosexual, that is, gay or lesbian, or prefer to have sex with people of your own sex; Don't Know Thinking of the last five years, that is since (SEASON) of (YEAR), has the partner or partners in your sexual relationships been: Only men, Mostly men, About the same number of men and women, Mostly women, Only women, or Have you not had a sexual relationship in the last five years?	PI: Alcohol Epidemiologic Data System Email: AEDSinfo@csrincorporated.com

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
National College Health Assessment[31-33] achancha.org/			Population: college students at select U.S. colleges and universities Age ≥ 18 years old Size: Varies; Spring 2015: 93,000	Biannually 2000-present								NCHA I: Which of the following best describes you? Heterosexual, Bisexual, Unsure, Gay/Lesbian, Transgendered Within the last 12 months, were your sexual partner(s), if any, N/A, Female, Male, Both Male and Female NCHA II: What is your sexual orientation? Heterosexual, Gay/Lesbian, Bisexual, Unsure Within the last 12 months, did you have sexual partner(s) who were: (Please mark the appropriate column [Yes/No] for each row) Female, Male, Transgender NCHA IIc: What term best describes your sexual orientation? Asexual, Bisexual, Gay, Lesbian, Pansexual, Queer, Questioning, Same Gender Loving, Straight/Heterosexual, Another identity (please specify) Within the past 12 months, did you have sexual partner(s) who were: Women, Men, Trans women, Trans men, Genderqueer, Persons with another identity	PI: American College Health Association Email: mhoban@acha.org Phone: 410-859-1500 Data access: requires application More information on data access: acha-ncha.org/research.html
National Comorbidity Survey[34-36] hcp.med.harvard.edu/ncs/			Population: non-institutionalized, U.S. residents Age ≥ 18 years old Size: NCS-1: 8,000 NCS-2: 5,000 NCS-R: 10,000	NCS-1: 1990-1992 NCS-2: 2001-2002 NCS-R: 2001-2003								Which of the categories on the card best describes you? Heterosexual (straight), Gay or lesbian, Bisexual, Not sure In the past five years, how many [men/women] have you had sexual intercourse with? (Circle one category) None, One, Two-Five, Six-Ten, More Than Ten Relationship roster includes relationship to respondent and sex	PI: Ronald Kessler Email: NCS@hcp.med.harvard.edu Data access: Publicly available for NCS and NCS-R. NCS-R require a restricted use dataset application. NCS-2 data are restricted and require application:http://www.hcp.med.harvard.edu/ncs/

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
National Drug Strategy Household Survey[37] http://www.aihw.gov.au/alcohol-and-other-drugs/data-sources/about-ndshs/			Australian population Age ≥ 12 Size: Varies 2013: 24,000	Every three years 1998-present								Do you think of yourself as…? heterosexual or straight; homosexual (gay or lesbian); bisexual; not sure, undecided: something else	PI: Australian Institute of Health and Welfare Email: Open.data@aihw.gov.au Data access: http://data.gov.au/dataset/aa3cb47f-b3b4-492a-8f98-c6013beb814e
National Epidemiologic Survey on Alcohol and Related Conditions[38] niaaa.nih.gov/research/nesarc-iii			Population: non-institutionalized, U.S. residents Age ≥ 18 years Size: Wave 1: 43,100 Wave 2: 34,700 Wave 3: 36,300	Wave 1: 2001-2002 Wave 2: 2004-2005 Wave 3: 2012-2013 Longitudinal								Which of the categories on the card best describes you? Heterosexual (straight), gay or lesbian, bisexual, not sure In your entire life, have you had sex with only males, only females, both males and females, or have you never had sex? People are different in their sexual attraction to other people. Which category on the card best describes your feelings? Only attracted to females, mostly attracted to females, equally attracted to males and females, mostly attracted to males, only attracted to males	PI: National Institute on Alcohol Abuse and Alcoholism (NIAAA) Contact: Nekisha Lakins, CSR Incorporated Email: nlakins@csrincorporated.com Phone: 703-741-7157 Data access: Researchers interested in accessing NESARC datasets should contact Aaron White, PhD at aaron.white@nih.gov or 301-451-5943.

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
National Health and Nutrition Examination Study[39] cdc.gov/nchs/nhanes.htm			Population: civilian, non-institutionalized U.S. residents Age: all ages Size: 5,000	Annually 1999-present								Do you think of yourself as heterosexual or straight (that is, sexually attracted only to [men/women]); homosexual or gay (that is, sexually attracted to only [women/men]); bisexual (that is, sexually attracted to men and women); something else? In the past 12 months, with how many [men/women] have you had sex? In your lifetime, with how many [men/women] have you had sex?	PI: Centers for Disease Control and Prevention Phone: 800-232-4636 Data access: Series available for download at cdc.gov/nchs/nhanes/nhanes_questionnaires.htm More information about data access: can be pooled across survey years to create large sample sizes; CDC provides guidance at cdc.gov/nchs/tutorials/Nhanes/index_continuous.htm
National Health and Social Life Survey[40] popcenter.uchicago.edu/data/nhsls.shtml			Population: U.S. residents of two metropolitan areas Age 18-59 years old Size: 3,400	1992								Do you think of yourself as… Heterosexual, Homosexual, Bisexual, Something Else, Normal/Straight, Don't Know Have your sex partners in the last 12 months been… exclusively male; both male and female; female? Have your sex partners in the last 5 years been… exclusively male; both male and female; female? Now thinking about the time since your 18th birthday (including the recent past you've already told us about) how many {female/male} partners have you had sex with?	PI: Edward Laumann, PhD Email: sscs-data-archive@listhost.uchicago.edu Data access: available for download at study website or dx.doi.org/10.3886/ICPSR06647

Table 2.1 continued

Name/ Study Website	Sampling design				Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability	Study design	Years	Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
National Health and Social Life Survey[40] (continued)												Now thinking about the time since your 18th birthday and during the time before you started living with [(S)pouse/ (C)ohabitant], how many people, including men and women, did you begin having sex with, even if only one time? If one: Was this partner a male or female? If two or more: How many of these partners were... (a) male? (b) female? Now, I am going to ask you some questions about any other sexual partners you may have had during the time you were living with (1st S/C)… On a scale of 1 to 4, where 1 is very appealing and 4 is not at all appealing, how would you rate each of these activities:….b) having sex with someone of the same sex. In general, you are sexually attracted to 1) only men 2) mostly men 3) both men and women 4) mostly women 5) only women Relationship roster includes relationship to respondent and sex	
National Health Interview Survey (NHIS)[41] cdc.gov/nchs/nhis.htm			Population: civilian, non-institutionalized U.S. residents Age: all ages Size: 87,500	1972-1993 Annually 1994-2014 Even-numbered years								Which of the following best represents how you think of yourself? Gay; Straight, that is, not gay; Bisexual; Something Else; I don't know the answer [Are you/Is ALIAS] male or female? What is [ALIAS's] relationship to [you]? Spouse (husband/wife], Unmarried partner	PI: Centers for Disease Control and Prevention Phone: 800-432-4636 Data access: Series available for download at cdc.gov/nchs/nhis/nhis_questionnaires.htm

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
National Intimate Partner and Sexual Violence Survey[42] http://www.icpsr.umich.edu/icpsrweb/NACJD/studies/34305			Population: U.S. men and women Age ≥ 18 Size: 18,000	2010								Do you consider yourself to be…? Heterosexual or straight, Gay or lesbian, Bisexual, Transgendered During your lifetime, have you had sex with only men, only women, or both men and women? Only men, Only women, Both men and women, Other (specify), Neither	Phone: 800-999-0960 Email: nacjd@icpsr.umich.edu Data Access: http://www.icpsr.umich.edu/icpsrweb/NACJD/studies/34305
National Latino and Asian American Study[43] http://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/00191#bibcite			National U.S. community and household sample of adults Age ≥ 18 years Size: 4,600	2002-2003								We would like to ask you some questions about your sexual preference. We would like to know how you best describe yourself. Please read the question and tell me the letter corresponding to your answer: heterosexual; homosexual, lesbian, gay; bisexual; something else; not sure Thinking back on the past 12 months, have your sexual experiences been with… females only, mostly females, about equal numbers of males and females, mostly males, all males	PI: Margarita Alegria Data Access: http://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/20240

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
National Longitudinal Study of Adolescent to Adult Health[44] cpc.unc.edu/projects/addhealth			Population: U.S. in-school adolescents Age: grades 7-12 Size: 14,400	1994-2008 Longitudinal								Choose the description that best fits how you think about yourself: 100% heterosexual (straight); Mostly heterosexual (straight) but somewhat attracted to people of your own sex; Bisexual that is, attracted to men and women equally; mostly homosexual (gay), but somewhat attracted to people of the opposite sex; 100% homosexual (gay); Not sexually attracted to males or females; Not sure. Considering all types of sexual activity, with how many [females/males] have you had sex over the past 12 months, even if only one time? Considering all types of sexual activity, with how many [female/male] partners have you ever had sex? Are you romantically attracted to [females/males]? Identify romantic and sexual partners, including their gender, in a partnership roster	PI: Add Health Study Team Email: addhealth@unc.edu Data access: sexual minority data require restricted use application, IRB approval, data security plan, $850 fee. More information on data access: http://www.icpsr.umich.edu/icpsrweb/DSDR/studies/21600
National Research Consortium of Counseling Centers in Higher Education[45] https://www.cmhc.utexas.edu/rc_datasets.html			Population: stratified random sample of students from 70 U.S. institutions of higher education Age ≥ 18 years Size: 108,500									How would you describe your sexual orientation? Bisexual; Gay or lesbian; Heterosexual; Questioning; Other, please specify	Contact: University of Texas Counseling and Mental Health Center Data Access: https://www.cmhc.utexas.edu/rc_datasets.html

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
National Social Life, Health, and Aging Project[46] norc.org/nshap			Population: community-residing, U.S adults Age 57-85 Size: Wave 1: 3,000 Wave 2: 3,400	Wave 1: 2005-2006 Wave 2: 2010-2011								First, in what month and year did you first have sexual activity with (CURRENT OR MOST RECENT SPOUSE/COHAB THAT BEGAN W/IN LAST 5 YEARS, OR CURRENT ROMANTIC PARTNER'S NAME)? Is this person male or female? Thinking about the most recent person you had sexual activity within the last five years, In what month and year did you first have sexual activity with that person, even if it was more than five years ago? Is this person male or female? Thinking about the (most recent/ second most recent/ third most recent) person you had sexual activity within the last five years). In what month and year did you first have sexual activity with that person, even if that first time was more than five years ago? Is this person male or female? Which of the following best describes (name's) relationship to you? Spouse, Romantic/Sexual Partner	PI: Linda Waite, PhD Phone: 773-256-6333 Email: l-waite@uchicago.edu Data access: requires restricted use application and IRB approval More information on data access: dx.doi.org/10.3886/ICPSR20541
National Survey of Family Growth[47] cdc.gov/nchs/nsfg.htm			Population: non-institutionalized, U.S. residents Age 15-44 Size: 12,600	2002, Wave 6 2006-2010 2011-2013								Do you think of yourself as…Heterosexual or straight; Homosexual, gay, or lesbian; or Bisexual Thinking about the last 12 months, how many [male/female] sex partners have you had in the 12 months since (INTERVIEW MONTH)? Please count every partner, even those you had sex with only once in those 12 months. Have you ever had any sexual experience of any kind with another [male/female]?	PI: National Center for Health Statistics Data access: sexual minority data restricted and require a data request and user agreement More information: cdc.gov/nchs/nsfg/nsfg_questionnaires.htm

Table 2.1 continued

Name/ Study Website	Sampling design				Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability	Study design	Years	Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
National Survey of Family Growth[47] (continued)												People are different in their sexual attraction to other people. Which best describes your feelings? Are you...only attracted to females, mostly attracted to females, equally attracted to males and females, mostly attracted to males, only attracted to males What is X's relationship to you? Husband, Male partner, Wife, Female partner	
National Survey on Drug Use and Health[4] samhsa.gov/data/population-data-nsduh/reports			Population: non-institutionalized, U.S. residents Age ≥ 12 years Size: 70,000	1971-Present								Which of the following do you consider yourself to be? Heterosexual, that is straight; Lesbian or Gay; Bisexual During the past 12 months, have you had sex with only males, only females, or with both males and females? Remember: by sex we mean only vaginal, oral or anal. Please only mark one box for the best answer. People are different in their sexual attraction to other people. Which statement best describes your feelings? I am only attracted to females, I am mostly attracted to females, I am equally attracted to females and males, I am mostly attracted to males, I am only attracted to males, I am not sure.	PI: Substance Abuse and Mental Health Services Administration Data access: 1996 data and documentation available for download: dx.doi.org/10.3886/ICPSR02391 For more information about NSDUH data, see https://www.samhsa.gov/data/population-data-nsduh/reports?tab=38 or contact samhda-support@samhsa.hhs.gov

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
National Survey of Sexual Attitudes and Lifestyles[48-50] http://www.natsal.ac.uk/home.aspx			General population survey in the U.K. Natsal-1: Age: 16-59 years Size: 18,900 Natsal-2: Age: 16-44 years Size: 12,110 Natsal-3: Age: 16-74 years Size: 15,000	Natsal-1: 1990-1991 Natsal-2: 1999-2000 Natsal-3: 2010-2012								Which of the options on this card best describes how you think of yourself? Response options: Just tell me the letter next to the description on this card: Heterosexual/straight, gay/lesbian, bisexual, other. Altogether, in your life so far, how many (men/women—same sex) have you had sex with (that is oral, or anal, or other forms of genital contact)?	PI: Bob Erens Email: c.mercer@ucl.ac.uk Telephone: 0800 783 5890
National Violence Against Women Survey[51] http://www.icpsr.umich.edu/icpsrweb/NACJD/studies/2566			U.S. sample of adults Age ≥ 18 years Size: 8,000 men and 8,000 women	1994-1996								Are you currently living as a couple with a woman/man? Have you ever lived as a couple with a woman/man? How many women/men have you lived with as a couple?	PI: Patricia Tjaden Data access: http://www.icpsr.umich.edu/icpsrweb/NACJD/studies/2566

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
New York City Community Health Survey[52] https://www1.nyc.gov/site/doh/data/data-sets/community-health-survey.page			Cross-sectional NYC residents from the five boroughs; adults Age ≥ 18 years Size: 8,500	Annually 2002-2014								Now I'll read a list of terms people sometimes use to describe themselves…heterosexual or straight, homosexual, gay or lesbian, and bisexual. As I read the list again, please stop me when I get to the term that best describes how you think of yourself. Heterosexual or straight; Homosexual, gay or lesbian; Bisexual, Don't know/not sure For women: During the past 12 months, with how many women have you had sex? READ IF NEEDED: By sex we mean oral, vaginal or anal sex but not masturbation. For men: During the past 12 months, with how many men have you had sex? READ IF NEEDED: By sex we mean oral or anal sex but not masturbation.	Contact: CHS coordinator, NYC Department of Health and Mental Hygiene Email: survey@health.nyc.gov Data access: https://www1.nyc.gov/site/doh/data/data-sets/community-health-survey-public-use-data.page
New York City Health and Nutrition Examination Survey[53] http://nychanes.org/data/			Cross-sectional non-institutionalized sample of NYC residents; Age ≥ 20 years Size: 1,500	2013-2014								Do you think of yourself as… Response options: Heterosexual/straight, homosexual, gay/lesbian, bisexual, don't know, not sure. In your lifetime have you had any type of sex with man/woman (same sex)?	Email: info@nychanes.org Phone: 347-396-4171 Data access: http://nychanes.org/data/
Nurses' Health Study II[54] channing.harvard.edu/nhs/			Population: Nurses from CA, CT, IN, IA, KY, MA, MI, MO, NY, NC, OH, PA, SC, TX in 1989 Age 25-42 years Size: 116,700	Biennially 1989-present Longitudinal								Whether or not you are currently sexually active, what is your sexual orientation or identity (please choose one answer): heterosexual; lesbian, gay or homosexual; bisexual; none of these; prefer not to answer.	PI: Nurses' Health Study Phone: 617-525-2279 Email: nhs2@channing.harvard.edu Data access: Proposal, identification of collaborator, approval of advisory committee; data production and statistical analysis costs.

Table 2.1 continued

Name/ Study Website	Sampling design		Study design	Years	Questions							Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
Personality & Total Health Through Life[55] crahw.anu.edu.au/research/projects/personality-total-health-path-through-life			Population: Canberra and Queanbeyan, Australia residents Age 20-24, 40-44, and 60-64 at baseline Size: 20+ cohort: 2,400 40+ cohort: 2,500 60+ cohort: 2,500	1999-present Longitudinal								Would you currently consider yourself to be predominantly Heterosexual, Homosexual, Bisexual, Don't know	PI: Kaarin Anstey, PhD Phone: +61-2-6125 8410 Email: Kaarin.Anstey@anu.edu.au Information on data access: http://crahw.anu.edu.au/research/projects/personality-total-health-path-through-life/data
Project on Human Development in Chicago Neighborhoods[56] http://www.icpsr.umich.edu/icpsrweb/PHDCN/about.jsp			Population: adolescents, children, and their caregivers from randomly sampled neighborhoods in Chicago, IL; longitudinal Size: 6,200	1994-1997, 1997-1999, 2000-2001								Which of the following best describes your feelings? 100% heterosexual (only attracted to person of the opposite sex); mostly heterosexual (attracted to both, but mostly persons of the opposite sex); bisexual (pretty much equally attracted to both men and women); mostly homosexual (attracted to both, but mostly persons of the same sex); 100% homosexual (gay/lesbian; only attracted to persons of the same sex); not sure	PI: Felton Earls Email: phdcn@icpsr.umich.edu Data access: http://www.icpsr.umich.edu/icpsrweb/PHDCN/daa.jsp

Table 2.1 continued

Name/ Study Website	Sampling design			Questions								Specific Questions	PI/Contact & Data Access
	Probability	Non-probability	Study design	Years	Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
United States Census[57] census.gov			Population: non-institutionalized, U.S. residents Age: all ages Size: Varies	1990, 2000, 2010								How is this person [Person 2] related to Person 1? Husband or wife, Unmarried Partner What is Person 2's sex? Male Female	PI: United States Department of Commerce, United States Census Bureau Phone: 1-800-923-8282 Data access: factfinder.census.gov/
Women's Health Initiative[58] nhlbi.nih.gov/whi/			Population: Women from 40 U.S. Clinical Centers; Age: 50-79 Observational: 161,800	1993-2015 Longitudinal								Which response best describes who you have had sex with after 45 years of age? Never had sex, Sex with a woman or with women, Sex with a man or with men, Sex with both men and women Regardless of whether you are currently sexually active, which response best describes who you have had sex with over your adult lifetime? Have never had sex, Sex with a woman or with women, Sex with a man or with men, Sex with both men and women, Prefer not to answer.	PI: Women's Health Initiative Phone: 301-402-2900 Email: helpdesk@whi.org Data access: Requires request and IRB approval. More information at http://www.ncbi.nlm.nih.gov/projects/gap/cgi-bin/study.cgi?study_id=phs000200.v10.p3

Table 2.1 continued

Name/ Study Website	Sampling design			Questions								Specific Questions	PI/Contact & Data Access
	Probability	Non-probability	Study design	Years	Sexual identity	Sexual behavior (past 30 days)	Sexual behavior (past 12 months)	Sexual behavior (past 5 years)	Sexual behavior (lifetime)	Attraction	Partner Status		
Youth2000[59] https://www.fmhs.auckland.ac.nz/en/faculty/adolescent-health-research-group/youth2000-national-youth-health-survey-series.html			Population: secondary school students from New Zealand; schools randomly selected throughout the country; cross-sectional Age: years 9-13 Size: 28,000	2001, 2007, 2012								Who are you sexually attracted to…? The opposite sex (e.g. I am a male attracted to females or I am a female attracted to males); The same sex (e.g. I am a male attracted to males or I am a female attracted to females); Both sexes (e.g. I am attracted to males and females); I'm not sure; Neither; I don't understand this question	PI: Terryann Clark Email: t.clark@auckland.ac.nz Phone: +64 9 923 7620 or +64 21 294 8354 Data access: https://www.fmhs.auckland.ac.nz/en/faculty/adolescent-health-research-group/collaborations-and-access-to-datasets.html#2e2c836f0e6f923183bc0e0884a0a954
Youth Risk Behavior Surveillance System[60] cdc.gov/HealthyYouth/yrbs/			*For national YRBS* Population: U.S. public and private school students Age: grades 9-12 Size: Varies	Biennially								Which of the following best describes you? Heterosexual (straight), Gay or lesbian, Bisexual, Not sure During your life, with whom have you had sexual contact? I have never had sexual contact, Females, Males, Females and Males	Email: cdcinfo@cdc.gov Data access: Combined dataset 1991-2013 available at http://www.cdc.gov/healthyyouth/data/yrbs/data.htm CDC will provide information on how to request data from jurisdictions where survey was conducted and in some cases can provide the data. More information on data access: cdc.gov/HealthyYouth/yrbs/contactyrbs.htm

Table 2.2 Gender minority-inclusive health surveillance data sources

Name/ Study Website	Sampling Design		Sample Characteristics	Study Years	Question Type				Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Single-item, general	Single item, specific	Single item, with probe	Two-item		
Behavioral Risk Factor Surveillance System[3,14] cdc.gov/brfss/			Population: non-institutionalized U.S. residents Age ≥ 18 years Size: Varies	Annual					Do you consider yourself to be transgender? Yes, Transgender, male-to-female; Yes, Transgender, female-to-male; Yes, Transgender, gender nonconforming; No; Don't Know/Not Sure	PI: Centers for Disease Control and Prevention Behavioral Survey Branch Data access: contact state-by-state project officers (https://www.cdc.gov/brfss/state_info/coordinators.htm) More information: See BRFSS state-added question database (https://www.cdc.gov/brfss/questionnaires/index.htm)
Growing Up Today Study[21] gutsweb.org/			Population: Children of Nurses' Health Study participants Age 9-14 in 1996 and 10-17 in 2004 Size: GUTS - 16,700 GUTS2 - 10,900	Annually since 1996 Longitudinal					How do you describe yourself? (Mark one answer) Female, Male, Transgender, Do not identify as female, male or transgender	Contact: Xenia Kumph, Project Manager Email: gutsadmin@channing.harvard.edu Data access: Investigators who are interested in using GUTS data or surveys should email the Project Manager.
Kaiser Permanente Member Health Survey[23] dor.kaiser.org/external/DORExternal/mhs/index.aspx			Population: northern California Kaiser health plan members Age ≥ 20 years Size: 42,000	1993-ongoing, every 3 years					What is your sex? Male, Female, Transgender (describe)	Nancy P. Gordon, ScD, Study Director, Research Investigator, Division of Research Phone: 510-891-3587 Email: nancy.gordon@kp.org dor.kaiser.org/external/Nancy_Gordon/

Table 2.2 continued

Name/ Study Website	Sampling Design		Sample Characteristics	Study Years	Question Type				Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Single-item, general	Single item, specific	Single item, with probe	Two-item		
National Adult Tobacco Survey[29] http://www.cdc.gov/tobacco/data_statistics/surveys/nats/			Population: US national stratified sample based on landline and cell phone of non-institutionalized people Age ≥ 18 years Size: Varies	2009-2010, 2012-2013					If answers "something else" to sexual orientation question (see Table 1 above): By something else, do you mean that…. Response options: "you are not straight, but identify with another label, such as queer, trisexual, omnisexual, or pan sexual", "you are transgender, transsexual, or gender variant", "you have not yet figured out your sexuality or in the process of figuring it out", "you do not think of yourself as having a sexuality" "you do not use labels to identify yourself", "you made a mistake and did not mean to pick this answer", and "you mean something else".	PI: Centers for Disease Control and Prevention Phone: 800-CDC-INFO Data access: http://www.cdc.gov/tobacco/data_statistics/surveys/nats/
National College Health Assessment[31-33] achancha.org/			Population: college students at select U.S. colleges and universities Age ≥ 18 years Size: Varies; Spring 2015: 93,000	Biannually 2000-present					NCHA I: Which of the following best describes you? Heterosexual, Gay/Lesbian, Bisexual, Transgendered, and Unsure NCHA II: What is your gender? Female, Male, Transgender NCHA IIc: Do you identify as transgender? No, Yes NCHA IIc: Which terms do you use to describe your gender identity: Woman, Man, Trans woman, Trans man, Genderqueer, Another identity	PI: American College Health Association Email: mhoban@acha.org Phone: 410-859-1500 Data access: requires application More information on data access: acha-ncha.org/research.html

Table 2.2 continued

Name/ Study Website	Sampling Design		Sample Characteristics	Study Years	Question Type				Specific Questions	PI/Contact & Data Access
	Probability	Non-probability			Single-item, general	Single item, specific	Single item, with probe	Two-item		
National Intimate Partner and Sexual Violence Survey[42] http://www.icpsr.umich.edu/icpsrweb/NACJD/studies/34305			Population: US men and women Age ≥ 18 years Size: 18,000	2010					Do you consider yourself to be… Heterosexual or straight, Gay or lesbian, Bisexual, Transgendered, DON'T KNOW	Phone: 800-999-0960 Email: nacjd@icpsr.umich.edu Data access: http://www.icpsr.umich.edu/icpsrweb/NACJD/studies/34305
National Research Consortium of Counseling Centers in Higher Education[45] https://www.cmhc.utexas.edu/rc_datasets.html			Population: stratified random sample of students from 70 U.S. institutions of higher education Age ≥ 18 years Size: 108,500						How do you identify? Female, Male, Transgender	Contact: University of Texas Counseling and Mental Health Center Data Access: https://www.cmhc.utexas.edu/rc_datasets.html
Youth2000[59] https://www.fmhs.auckland.ac.nz/en/faculty/adolescent-health-research-group/youth2000-national-youth-health-survey-series.html			Population: secondary school students from New Zealand; schools randomly selected throughout the country; cross-sectional Age: years 9-13 Size: 28,000	2001, 2007, 2012					Do you think you are transgender? This is a girl who feels like she should have been a boy, or a boy who feels like he should have been a girl. (e.g. Trans, Queen, Fa'faffine, Whakawahine, Tangata ira Tane, Genderqueer) Yes, No, I'm not sure, I don't understand this question	PI: Terryann Clark Email: t.clark@auckland.ac.nz Phone: +64 9 923 7620 or +64 21 294 8354 Data access: https://www.fmhs.auckland.ac.nz/en/faculty/adolescent-health-research-group/collaborations-and-access-to-datasets.html#2e2c836f0e6f923183bc0e0884a0a954

Chapter 3

Sexual Orientation Measurement and Chronic Disease Disparities: National Health and Nutrition Examination Survey, 2009-2014

This chapter represents a manuscript published by Joanne G. Patterson, and Jennifer M. Jabson:

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My contributions to this manuscript as the lead author include: (1) identifying the gap in evidence, (2) developing research questions, (3) designing study and analyses, (4) analyzing and interpreting quantitative data, and (5) primary authorship and editing of the final manuscript.

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Abstract

Purpose

To examine chronic disease disparities by sexual orientation measurement among sexual minorities.

Methods

We pooled data from the 2009–2014 National Health and Nutrition Examination Survey to examine differences in chronic disease prevalence between heterosexual and sexual minority people as defined by sexual identity, lifetime sexual behavior, 12-month sexual behavior, and concordance of lifetime sexual behavior and sexual identity.

Results

Self-identified lesbian women reported greater odds of asthma (adjusted odds ratio [aOR], 3.19; 95% confidence intervals [CI], 1.37–7.47) and chronic bronchitis (aOR, 2.64; 95% CI, 1.21–5.72) than self-identified heterosexual women. Self-identified sexual minority women with a history of same-sex sexual behavior reported greater odds of arthritis (aOR, 1.67; 95% CI, 1.02–2.74). Compared with heterosexual men, gay men reported greater odds of chronic bronchitis when sexual orientation was defined by sexual identity (aOR, 4.68; 95% CI, 1.90–11.56) or 12-month sexual behavior (aOR, 3.22; 95% CI, 1.27–8.20), as did bisexual men defined by lifetime sexual behavior (aOR, 2.36; 95% CI, 1.14–4.89). Bisexual men reported greater odds of asthma when measured by lifetime sexual behavior (aOR, 1.90; 95% CI, 1.12–3.19), as did self-identified heterosexual men with a history of same-sex sexual behavior (aOR, 2.21; 95% CI, 1.10–4.46).

Conclusions

How we define sexual orientation influences our understanding of chronic disease prevalence. Capturing subgroups of sexual minority people in health surveillance is essential for identifying groups most at risk and developing targeted interventions to reduce chronic disease disparities.

Introduction

Population-level evidence indicates that sexual minority people (SMP; i.e., lesbian, gay, and bisexual people) have higher chronic disease prevalence compared with their heterosexual counterparts.[1] Chronic diseases are leading causes of death and disability. Identifying subpopulations of SMP that experience disproportionate rates of chronic diseases is vital for developing targeted interventions to reduce disparities and promote health equity. The gold standard for sexual orientation measurement is to assess three distinct dimensions of sexual orientation—sexual identity, sexual behavior, and attraction.[2] However, most public health surveillance programs measure sexual orientation based on single-item measurement.[3] This is problematic because estimates of health disparities differ depending on how sexual orientation is measured.[4,5] For example, among adolescents[4] and college-aged adults,[5] disparities in health risk behaviors—including alcohol (college-aged only), tobacco, and illicit drug use—were generally greater when sexual orientation was measured by sexual identity as compared with sexual behavior or attraction (college-aged only). In addition, in this example, the patterns were not consistent across sexual orientation categories; among bisexual respondents, health disparities were greater when sexual orientation was measured by sexual behavior as compared to sexual identity or attraction. Based on how health risks differ depending on how sexual orientation is measured, it is possible that chronic disease outcomes may also differ depending on how sexual orientation is measured.

A growing body of evidence—including several systematic reviews and two Institute of Medicine reports[1,6]—indicates that sexual minorities are at higher risk for cardiovascular disease (CVD)[7] and specific cancers[8] and experience higher prevalence of asthma (sexual minority women [SMW] only)[9,10] and arthritis (SMW only).[10] However, the existing literature is muddied by differences in sexual orientation measurement. The majority of extant literature on chronic disease disparities among SMP measures sexual orientation by identity; that is, whether someone self-identifies as lesbian, gay, bisexual, or heterosexual. In these studies, SMW reported increased odds of arthritis (lesbian women: 2.14),[11] CVD (1.37–3.71),[12,13] asthma (1.58–1.68),[14,15] diabetes (bisexual women: 1.8),[15] obesity (lesbian women: 2.05–2.47),[14,16] and hypertension (lesbian women: 1.60[12] and bisexual women: 1.50–1.60[15,17]) as heterosexual women. Self-identified sexual minority men (SMM) reported increased odds of arthritis (bisexual men: 2.12),[11] CVD (gay men under age 40: 2.78),[12] cancer (gay men: 1.9),[18] asthma (gay men:

1.32),[19] diabetes (SMM aged 50–70 years: 1.28),[19] and hypertension (1.9–2.0),[19,20] as heterosexual men.

However, single-item measurement may misrepresent or entirely miss disease patterns among SMP. Preliminary evidence suggests that measuring sexual orientation with behavioral measures influences patterns of chronic diseases. Two studies combined measures of lifetime same-sex sexual behavior and sexual identity to examine disparities among self-identified heterosexuals with a history of same-sex sexual behavior. Self-identified heterosexual women with a history of same sex sexual behavior were 2.88 times more likely to have asthma as exclusively heterosexual women,[21] and self-identified heterosexual men with a history of same-sex sexual behavior reported greater odds of asthma (3.45)[21] and CVD (6.28)[21] and were more likely to have diabetes (5.5% vs. 4.4%)[22] as exclusively heterosexual men. Estimates for self-identified heterosexuals with a history of same-sex sexual behavior are significantly higher than rates described previously among those SMP whose sexual orientation was measured by sexual identity. This difference suggests that examining sexual orientation measurement could be important to understanding patterns of chronic diseases among SMP.

The purpose of the present study was to examine chronic disease prevalence and disparities among subpopulations of SMP by four measures of sexual orientation. Consistent with minority stress theory, we hypothesized that chronic disease prevalence estimates would be higher among self-identified SMP than among those measured by sexual behavior.

Minority stress theory—the predominant explanation for health disparities among SMP[1,23]—suggests that SMP experience distal (e.g., prejudice, discrimination, and victimization) and proximal (e.g., internalized homophobia, expectations of rejection, and concealment of identity) stressors that are related specifically to non-heterosexual sexual orientation. SMP defined by specific dimensions of sexual orientation (e.g., identity or behavior) may differentially experience minority stressors, which in turn may influence levels of accumulated stress and related health outcomes, including chronic diseases.[23] For example, proximal stressors are subjective and related to self-identity as lesbian, gay, or bisexual. The more someone identifies as an SMP, the greater impact proximal stressors are theorized to have on health outcomes.[23] As such, individuals who self-identify as SMP may be at greater risk for experiencing poor health outcomes driven by proximal minority stressors than self-identified heterosexuals with a history of same-sex sexual behavior.

Methods

Data

Publicly available data from the National Health and Nutrition Examination Survey (NHANES), pooled across 5 years, 2009 to 2014, were used. NHANES is a national probability, repeated cross-sectional survey of U.S. adults and children ≥12 years that assesses health and nutritional status using interviews and physical exams.[24,25] Detailed information about NHANES study design and sampling frame is described elsewhere.[24,25]

NHANES data are ideal for studying the health of SMP as data can be pooled across years to provide larger sample sizes. Survey response rates ranged from 71.0% to 79.4%, and medical examination completion rates ranged from 68.5% to 77.2% for the 6- year period. From 2009 to 2014, 6609 women and 6560 men completed the sexual behavior survey, which included sexual orientation measures for female and male respondents. Respondents were excluded from analysis if they did not answer the sexual identity, lifetime same-sex sexual behavior, or 12-month same-sex sexual behavior questions; responded as “something else” (women: n = 41, 0.4%; men: n = 28, 0.6%), “not sure” (women: n = 121, 1.1%; men: n = 46, 0.3%), or “don't know” (women: n = 24, 0.04%; men: n = 29, 0.4%) to sexual orientation questions; did not answer chronic disease questions; did not answer tobacco use questions; did not provide height or weight data; or were under age 18 or over age 59. The final analytic sample included 5860 women and 5483 men.

Sexual Orientation

NHANES measured sexual orientation with one question about sexual identity and two questions about sexual behavior. Female and male respondents aged 14–69 years were asked about their sexual identity. Female respondents were asked, “Do you think of yourself as heterosexual or straight (i.e., sexually attracted only to men); homosexual or gay (i.e., sexually attracted only to women); bisexual (i.e., sexually attracted to men and women); something else?” Female respondents reporting a lesbian or bisexual identity were defined as SMW (coded 1) and those reporting a heterosexual identity as heterosexual women (coded 0). For subgroup analyses, female respondents were defined by self-identification as bisexual (coded 2), lesbian (coded 1), or heterosexual (coded 0). Male respondents were asked, “Do you think of yourself as heterosexual or straight (i.e., sexually attracted only to women); homosexual or gay (i.e., sexually attracted only to men); bisexual (i.e., sexually attracted to women and men);

something else?" Male respondents reporting a gay or bisexual identity were defined as SMM (coded 1) and those reporting a heterosexual identity as heterosexual men (coded 0). For subgroup analyses, male respondents were defined by self-identification as bisexual (coded 2), gay (coded 1), or heterosexual (coded 0).

NHANES assessed sexual behavior only for respondents who indicated that they had ever engaged in sexual activity. Female respondents aged 14–59 years were asked lifetime and 12-month same-sex sexual behavior questions. Male respondents aged 14–69 years were asked lifetime same-sex sexual behavior questions, whereas male respondents 14–59 years old were asked 12-month same-sex sexual behavior questions. Respondents were asked to provide the total number of same-sex and opposite-sex partners during their lifetime and over the past 12 months. For lifetime same-sex behavior measures, female and male respondents reporting at least one same-sex sexual partner over the life course were defined as either SMW or SMM (coded 1) and women or men reporting only opposite-sex partners over the life course as either heterosexual women or men (coded 0). For subgroup analyses, women or men reporting at least one same-sex and at least one opposite-sex sexual partner over the life course were defined as bisexual (coded 2), women or men reporting only same-sex partners over the life course were defined as lesbian or gay (coded 1), and women or men reporting only opposite-sex partners over the life course as heterosexual (coded 0). For 12-month same-sex behavior measures, female and male respondents reporting at least one same-sex sexual partner during the past 12 months were defined as either SMW or SMM (coded 1) and women or men reporting only opposite-sex partners during the past 12 months as either heterosexual women or men (coded 0). For subgroup analyses, women or men reporting at least one same-sex and at least one opposite-sex sexual partner over the past 12 months were defined as bisexual (coded 2), women or men reporting only same-sex partners over the past 12 months were defined as lesbian or gay (coded 1), and women or men reporting only opposite-sex partners over the past 12 months as heterosexual (coded 0).

Female and male respondents identifying as heterosexual but reporting at least one same-sex sexual partner over the life course were defined as self-identified heterosexual women or men with a history of same-sex sexual behavior (coded 2). Respondents reporting either bisexual or lesbian or gay identities and at least one same-sex sexual partner over the life course were defined as self-identified SMW or SMM with a history of same-sex sexual behavior (coded 1). Women or men identifying as heterosexual and reporting only opposite-sex partners over the

life course were defined as either exclusively heterosexual women or men (exclusively heterosexual; coded 0).

Chronic Disease

The following chronic diseases were included: asthma, cancer, chronic bronchitis, diabetes, heart attack, and hypertension. For each chronic disease, respondents self-reported if a health care provider had ever told them they had the disease in question. Respondents who indicated "Yes" (coded 1) were defined as having experienced that specific chronic disease. Respondents could report diagnosis of more than one chronic disease.

Sociodemographics

Respondents' education, race/ethnicity, marital status, and age were included as demographic characteristics. Education was recoded into four categories (< high school, high school/GED, some college/AA degrees, college graduate or above). Body mass index (BMI; i.e., weight in kilograms divided by height in meters squared) was calculated using weight and height measures taken during the medical examination. Obesity was defined as having a body mass index ≥30 kg/m2.[26] Current smoking was assessed with the question "Have you smoked at least 100 cigarettes in your entire life?" and the conditional follow-up question "Do you now smoke cigarettes?" Respondents who reported not smoking 100 cigarettes in their lifetime or having smoked at least 100 cigarettes in their lifetime but currently not smoking were coded as not smokers (coded 0) and those who reported currently smoking cigarettes either "every day" or "some days" were defined as current smokers (coded 1).

Analyses

Three sets of analyses were calculated. First, summary and descriptive statistics described the sample. Likelihood ratio X2 test for proportions was used to assess differences between SMP and heterosexual respondents and identify covariates. Weighted bivariate analyses were used to examine differences in chronic disease prevalence by sexual orientation measurement. Likelihood ratio X2 test for proportions was used to assess for statistical significance. Weighted point estimates were reported as percentages with standard errors, associated test statistics, and P-values. Nested weighted multivariable logistic regression models were used to estimate associations between sexual orientation and chronic disease prevalence by sexual orientation measurement. Nested analyses were first adjusted for demographic covariates (model 1) for which there were significant differences between groups, including age, race/ethnicity, and level

of education (Table 1). In the second model, current smoking was added as a covariate (model 2). The final model included demographic variables, current smoking, and obesity (model 3; full model). Exponentiated logistic regression coefficients were reported as adjusted odds ratios (aORs) with 95% confidence intervals (CIs). Heterosexuals served as the referent group in each model. STATA 14.2 (StataCorp LP, College Station, TX) was used for all analyses. Analyses were weighted for complex survey design using design information and weights as specified in NHANES' Analytic and Reporting Guidelines.[27] Analyses were conducted separately for women and men as recommended by the Institute of Medicine [1]. This was a secondary analysis of de-identified data and did not require a human subject's review.

Results

Sociodemographics

Table 3.1 summarizes respondent's demographic characteristics by sexual orientation measurement. Sample sizes for SMW and SMM differed by sexual orientation measurement. The greatest proportion of SMW were defined by lifetime sexual behavior (lesbian: 0.3% and bisexual: 10.1%), followed by lifetime sexual behavior and sexual identity (self-identified SMW with a history of same-sex sexual behavior: 5.1% and self-identified heterosexual women with a history of same-sex sexual behavior: 5.0%), sexual identity (lesbian: 1.3% and bisexual 4.8%), and 12-month sexual behavior (lesbian: 1.4% and bisexual 2.6%). The greatest proportion of SMM were defined by lifetime sexual behavior (gay: 1.3% and bisexual 4.0%), followed by lifetime sexual behavior and sexual identity (self-identified SMM with a history of same-sex sexual behavior: 3.0% and self-identified heterosexual men with a history of same-sex sexual behavior: 2.1%), sexual identity (gay: 2.0% and bisexual 1.4%), and 12-month sexual behavior (gay: 2.3% and bisexual: 0.6%).

Across all sexual orientation measures, most SMP in this sample identified as non-Hispanic white and were younger than their heterosexual counterparts. Education levels varied with fewer SMW and more SMM reporting a college education or above than did heterosexual women or men. Both SMW and SMM reported higher frequency of being never married or living with a partner as heterosexual women or men.

Differences in Chronic Diseases by Sexual Orientation Measurement

When sexual orientation was measured by sexual identity, weighted prevalence estimates indicated that SMW were more likely to report having asthma and chronic bronchitis compared with heterosexual women (Table 3.2), and this difference persisted by the subgroup (i.e., lesbian or bisexual). However, adjusted regression models (Table 3.3) revealed that the magnitude of the effect differed by sexual orientation measurement and by the sexual minority subgroup. SMW measured by sexual identity evidenced 1.79 odds of arthritis (aOR, 1.79; 95% CI, 1.12–2.86) as heterosexual women, and subgroup analysis indicated that both self-identified lesbian (aOR, 2.00; 95% CI, 1.02–3.91) and bisexual women (aOR, 1.89; 95% CI, 1.05–3.40) reported greater prevalence of arthritis than their heterosexual counterparts after controlling for smoking in the second model. However, these disparities disappeared when obesity was controlled for in the full model. Self-identified SMW had greater odds of asthma (aOR, 1.98; 95% CI, 1.32–2.98) as heterosexual women, and this disparity persisted for self-identified lesbian (aOR, 3.19; 95% CI, 1.37–7.47) and bisexual (aOR, 1.70; 95% CI, 1.12–2.58) women. Self-identified lesbians were also more likely to report chronic bronchitis (aOR, 2.64; 95% CI, 1.21–5.72) as heterosexual women. Bisexual women measured by lifetime sexual behavior reported greater odds of asthma (aOR, 1.60; 95% CI, 1.16–2.20). Lesbian women measured by 12-month sexual behavior reported more than three times the odds of asthma (aOR, 3.01; 95% CI, 1.31–6.91) as heterosexual women. Women with a lifetime history of same-sex behavior who self-identified as sexual minority (i.e., lesbian or bisexual) reported 1.67 greater odds of arthritis (aOR, 1.67; 95% CI, 1.02–2.74) and 2.30 greater odds of asthma (aOR, 2.30; 95% CI, 1.45–3.65) than self-identified heterosexual women reporting exclusively heterosexual lifetime sexual behavior. No differences were observed between self-identified heterosexual women with a lifetime history of same-sex behavior and those reporting exclusively heterosexual lifetime sexual behavior.

Compared with analyses of women, analyses of men revealed unique differences in chronic disease prevalence by sexual orientation measurement (Tables 3.2 and 3.4). However, SMM were more likely than heterosexual men to report chronic bronchitis when measured by sexual identity (aOR, 3.31; 95% CI, 1.44–7.17), lifetime sexual behavior (aOR, 2.32; 95% CI, 1.04–5.20), or 12-month sexual behavior (aOR, 3.07; 95% CI, 1.24–7.58). However, the magnitude of effect also differed across sexual orientation measurement by the subgroup (i.e., gay or bisexual). Gay men conferred greater odds for chronic bronchitis when sexual orientation was defined by sexual identity (aOR, 4.68; 95% CI, 1.90–11.56) and 12-month sexual behavior

(aOR, 3.22; 95% CI, 1.27–8.20). When measured by lifetime sexual behavior, bisexual men had greater prevalence of chronic bronchitis (aOR, 2.36; 95% CI, 1.14–4.89). When measured by lifetime sexual behavior, gay men had more than twice the odds of reporting hypertension (aOR, 2.63; 95% CI, 1.40–4.93) as heterosexual men. Men with a lifetime history of same-sex behavior who self-identified as sexual minority (i.e., gay or bisexual) had greater odds of reporting chronic bronchitis (aOR, 3.60; 95% CI, 1.60–8.09) than self-identified heterosexual men reporting exclusively heterosexual lifetime sexual behavior. Men with a lifetime history of same-sex behavior who self-identified as heterosexual had greater odds of reporting asthma (aOR, 2.21; 95% CI, 1.10–4.46) than self-identified heterosexual men reporting exclusively heterosexual lifetime sexual behavior.

Discussion

This study examined chronic disease prevalence among SMW and SMM by four measures of sexual orientation. For SMW, when sexual orientation was measured by sexual identity, lesbians and bisexual women were more likely than heterosexual women to report diagnosis of asthma and arthritis, and lesbians were more likely to report chronic bronchitis. However, when sexual orientation was measured by 12-month sexual behavior, only lesbian women reported increased prevalence of asthma persisted compared with heterosexual women. These findings are consonant with existing literature concerning SMW chronic disease disparities.[14,15,21] No differences in chronic disease prevalence were observed between self-identified heterosexual women reporting lifetime same-sex sexual behavior and those reporting exclusively heterosexual lifetime sexual behavior.

SMM had higher odds of reporting chronic bronchitis as heterosexual men; however, these differences varied depending on how sexual orientation was measured. Specifically, gay men evidenced greater odds for chronic bronchitis when sexual orientation was measured by sexual identity and 12-month sexual behavior. However, when sexual orientation was measured by lifetime sexual behavior, bisexual men and self-identified SMM (i.e., gay or bisexual) who had engaged in lifetime same-sex behavior evidenced greater odds of chronic bronchitis. Similarly, when sexual orientation was measured by lifetime sexual behavior only, bisexual men reported greater prevalence of asthma. Gay men reported greater prevalence of hypertension when measured by lifetime same-sex sexual behavior. Finally, self-identified heterosexual men reporting a lifetime history of same-sex sexual behavior evidenced greater odds of asthma than

exclusively heterosexual men. These findings are consistent with evidence suggesting that self-identified heterosexual men reporting a lifetime history of same-sex sexual behavior may be at greater risk for chronic diseases.[21,22]

As hypothesized, chronic disease prevalence estimates differed depending on how sexual orientation was measured. Lesbian women defined by sexual identity had greater prevalence of chronic diseases than lesbian women defined by sexual behavior. This supports our initial hypothesis that self-identified SMP would evidence greater chronic disease disparities than those defined by sexual behavior. Minority stress theory posits that the excess, chronic stress experienced by sexual minorities is internalized and accumulates across the life course, resulting in physical health disparities.[23] The more an individual identifies as a sexual minority, the greater impact minority stressors are theorized to have on physical health.[23] Thus, an individual self-identifying as SMP would, theoretically, experience greater chronic disease disparities arising from minority stress than SMP measured by sexual behavior only. For women, this would explain differences in prevalence of chronic bronchitis by sexual identity and the lack of significant differences for self-identified heterosexual women with a history of same-sex sexual behavior across all chronic diseases in this study, yet it does not account for the increased magnitude of asthma evidenced in lesbian and bisexual women defined by 12-month sexual behavior. It is hypothesized, however, that recent sexual behavior (e.g., 12 months) is a close proxy for current sexual identity,[2] and there is also evidence that partnered SMW are at increased risk of experiencing minority stress.[28] If both assumptions are true, it may be that lesbians engaged in 12-month same-sex sexual behavior are more at risk of experiencing distal minority stressors (e.g., discrimination and victimization) due to their sexual minority identity and sexual relationships. This would explain chronic disease disparities among this group. It could also be that not all women who engage in same-sex behavior over the past 12 months are “out” about their sexual orientation. Minority stress theory hypothesizes that proximal stressors—including internalized homophobia, hypervigilance, and concealment of one's sexual minority orientation—contribute to excess stress over the life course. If lesbian women defined by 12-month same-sex sexual behavior are less “out” about their sexual orientation, this could also explain chronic disease disparities for this group.

Among men, results varied: Consistent with our hypothesis, gay men evidenced greater prevalence of chronic bronchitis when measured by sexual identity than behavior. However, for asthma and hypertension, differences were only apparent when sexual orientation was

measured by lifetime sexual behavior or lifetime sexual behavior and sexual identity (self-identified heterosexual men with a history of same-sex sexual behavior). These results suggest that minority stress may differentially impact subgroups of SMM. For example, since the HIV/AIDS crisis, black men on the down low (DL; i.e., men who do not acknowledge a sexual minority identity but engage in same-sex sexual behavior) have been erroneously blamed for rising HIV/AIDS incidence.[29] As such, DL black men are at risk for experiencing cultural-specific homophobia fueled by fear of HIV/AIDS[29,30] and accompanying victimization.[30] Given that experiencing external prejudice events is associated with poorer physical health for SMP,[31] DL men may be at increased risk for chronic disease disparities compared with their "out" (i.e., those self-identify as SMP) counterparts. This hypothesis warrants further examination in studies that oversample for SMP.

Multiple subgroups of SMW and SMM evidenced chronic disease disparities compared with heterosexuals even when controlling for differences in demographic characteristics, current smoking status, and obesity. This is especially important as disparities in risk behaviors among SMP—including tobacco use and obesity[1]—have been assumed to predict chronic disease disparities for these groups. This study suggests, however, that in addition to tobacco use and obesity, other factors (such as minority stress) may be contributing to chronic disease disparities among some subgroups of SMP. It is known that chronic stress has biological implications, including limiting the body's capacity to regulate inflammation—a risk factor in developing inflammatory diseases[32] including arthritis,[33] asthma,[34] and chronic bronchitis[35]—the same diseases for which subgroups of SMP in this study exhibit disparities. Evidence suggests that SMP exposed to high levels of stigma exhibit cortisol dysregulation,[36] which may promote inflammatory diseases.[37] Given that lesbian women and gay men defined by sexual identity or sexual behavior were more likely to evidence chronic disease disparities, it may be that these subgroups are most at risk for experiencing stigma due to sexism and heterosexism. If true, the excess stress that lesbians and gay men experience may contribute to cortisol dysregulation, thus explaining increased prevalence of chronic diseases compared with their heterosexual counterparts. It must be noted, however, that bisexual women and men defined by lifetime sexual behavior evidenced disparities for asthma and chronic bronchitis (men only) despite controlling for smoking and obesity. This may provide evidence that bisexual individuals engaged in same- and opposite-sex behavior across the lifespan are at risk for excess stress. The stigmatization of bisexual people from within the sexual minority community and by general society is documented in the scientific literature.[38,39] This dual experience of stigma could lead

to excess stress among bisexuals, contributing to cortisol dysregulation and disparities in inflammatory disease, including asthma and chronic bronchitis.

It is also possible that for some subgroups of SMP, chronic disease disparities are explained by differences in risk profiles. For example, in this study, lesbian and bisexual women defined by sexual identity evidenced greater prevalence of arthritis than heterosexual women; however, these differences disappeared when we accounted for obesity. Recent evidence, including a systematic review of CVD disparities, indicates that SMP consistently displayed elevated risk factors for CVD—including tobacco and illicit drug use.[7] Similarly, a study of older adults indicated that older SMM had twice the odds of smoking and heavy drinking (bisexual men only) than their heterosexual counterparts.[13] As such, the elevated prevalence of hypertension evidenced among gay men in this study may be explained by disparities in associated risk behaviors not examined in this study. Few population-based studies sufficiently examine whether the elevated prevalence of risk behaviors among SMP explains chronic disease disparities among these groups. Health surveillance studies that include measures of sexual orientation, assess risk behaviors and associated chronic diseases, and contain large enough samples for subgroup analyses by sexual orientation are necessitated. Only when we understand the extent to which risk behaviors account for chronic disease disparities among SMP, can we develop specific recommendations for interventions to prevent chronic disease disparities among this group.

Limitations

This study has several limitations. First, NHANES' multiple sexual orientation measures conflate sexual identity and sexual attraction. Each sexual identity response (e.g., "bisexual") is paired with a statement about sexual attraction (e.g., "sexually attracted to males and females"). This is problematic because respondents are faced with choosing one response that addresses multiple aspects of their sexual orientation in one question (identity and attraction). For the purposes of this study, we used this question as a proxy for measurement of sexual identity. However, theory tells us that self-identification as a sexual minority group member may not be concordant with sexual attraction.[40] Formative sexuality theory posits that three dimensions of sexual orientation—identity, behavior, and attraction—are distinct and may not overlap for all individuals. Measurement of multiple dimensions of sexual orientation helps researchers identify groups (e.g., individuals who neither identify as SMP nor engage sexual behavior but are attracted to people of the same sex) that may experience differences in chronic disease

prevalence and disparities. Failing to measure these distinct dimensions of sexual orientation limits our capacity to identify and better understand the risk and needs of these groups. Second, our operational definition of self-identified heterosexuals with a history of same-sex sexual behavior as individuals who self-identify as heterosexual with at least one lifetime same-sex behavioral experience may account for our lack of findings. Although previous studies using this operational definition indicated disparities for self-identified heterosexuals with a history of same-sex sexual behavior,[21,22] it may be that such a broad operationalization masks differences for vulnerable groups. For example, self-identified heterosexuals who engage in multiple same-sex relationships over the life course may differentially experience minority stress than self-identified heterosexuals with a single lifetime same-sex sexual experience. Targeted studies that assess multiple dimensions of sexual relationships (e.g., number of sexual partners, duration of sexual relationships, and importance of sexual relationships) may provide a more nuanced understanding of factors that increase risk for self-identified heterosexuals with a history same sex sexual behavior. We were also unable to control for all demographic variables that may be associated with differences in chronic disease prevalence. For example, marital status in NHANES is defined across six categories (see Table 1); however, respondents could theoretically identify with multiple categories (e.g., widowed but also currently living with a partner). Owing to the potential for measurement error embedded in the marital status variable, we did not include marital status as a control variable in our analyses. Furthermore, a large number of respondents did not complete the sexual behavior questionnaire, which may influence chronic disease estimates. Respondents who do not complete the sexual behavior questionnaire may have different chronic disease rates from those who choose to complete this module. It is important to note, however, that best practices for studies of SMP caution against comparing nonrespondents to other sexual orientation groups as it is unclear how nonrespondents would respond to sexual orientation questions and so may conflate analyses [2]. In addition, the sample size of sexual minority respondents is small, despite pooling 6 years of data. Small sample sizes limit the complexity of analyses and the statistical power to examine heterogeneity within SMP. Oversampling is a strategy used for capturing other underrepresented minority groups in health surveillance, including NHANES. To increase sample sizes and capture underrepresented groups of SMP, we must also oversample SMP. Finally, NHANES asks sexual orientation questions only for women up to age 59 and for men up to age 69 (12-month sexual behavior only). Expanding the age range of respondents for sexual orientation measures is important because sexual orientation remains salient across the life course and risk for developing chronic disease increases with age; as such, chronic disease

disparities may vary by sexual orientation among older adults. It is essential that sexual orientation measures are asked of older adults (>age 65) so that we can identify disparities among SMP across the life course.

Conclusion

This study highlights the importance of sexual orientation measurement in assessing disease patterns and disparities among subpopulations of SMP. Our findings suggest that health disparities among SMP can be identified using only one or two measures of sexual orientation. Specifically, for lesbians and gay men, measuring sexual orientation by sexual identity or 12-month sexual behavior was associated with chronic disease disparities compared with heterosexual women and men measured by sexual identity or 12-month sexual behavior. However, patterns were not universal across sexual minority groups; chronic disease disparities for bisexual women and men were present when sexual orientation was measured by lifetime sexual behavior. The gold standard for sexual orientation measurement is to assess the three dimensions of sexual orientation—sexual identity, sexual behavior, and attraction.[2] Measuring all three dimensions of sexual orientation may improve what we know about chronic diseases among SMP; however, few health surveillance programs follow best practice. Patterson et al. (2017) concluded that less than 15% of publicly available, English-language, health surveillance programs measured three dimensions of sexual orientation.[3] Health surveillance programs that do not use multiple sexual orientation measures neglect nuances in SMP membership. For example, the 40% of health surveillance programs capturing SMP by single-item sexual orientation measurement may miss hidden groups, including self-identified heterosexuals who have engaged in same-sex behavior.[3] The extent to which multiple sexual orientation measures capture groups of SMP is important because how we measure sexual orientation entirely shapes what we know about the health of SMP, including chronic disease patterns and disparities. Health surveillance programs must include more than one measure of sexual orientation, so that researchers can examine subgroups of SMP to identify those evidencing disparities. For space- and financially constrained health surveillance programs that can only assess one or two dimensions of sexual orientation (i.e., sexual identity and sexual behavior), careful consideration must be made regarding how measurement choices will affect observable or masked patterns in disease and health disparities for subgroups of SMP.

In addition to including multiple measures of sexual orientation in health surveillance programs, targeted and in-depth studies are needed to fully examine and resolve health inequities experienced by SMP. Targeted studies that examine how individual, interpersonal, and structural experiences of minority stress influence behavioral risk factors and chronic diseases are needed to support the development, testing, and implementation of effective, multilevel disparities-reducing interventions. These studies must be rigorous and designed to be sensitive to differences that may exist across subpopulations of SMP. For example, the results presented here may indicate that SMW and SMM experience the risks and exposures (such as minority stressors) that contribute to disease differently or they may experience different exposures and risks entirely, therefore, necessitating gender-specific interventions to reduce disparities. Similarly, self-identified SMP may respond differently to sexual orientation–specific cultural prompts than those defined solely by sexual behavior. Assessing acceptability of targeted behavioral interventions across subgroups of SMP by sexual orientation measurement is an essential step to developing effective risk-reducing interventions.

Finally, this study adds to a growing body of research indicating that SMP may bear a greater burden of chronic diseases than heterosexuals. To reduce chronic disease disparities and promote health equity, coordinated public health solutions must operate across multiple social ecological levels. At the federal and state levels, nondiscrimination policy is necessary to protect SMP from discrimination across multiple contexts (e.g., employment, housing, health care access, public accommodations). Population-level tobacco control policy at the federal and state levels must further prohibit the targeted marketing of tobacco to the sexual minority community. In addition, the alcohol industry must make the ethical choice to strengthen standards that limit exposure to alcohol marketing to vulnerable groups—including youth and SMP. Until comprehensive and protective policies are universally implemented, disparities-reducing solutions at multiple levels—including the individual level—can add to significant gains in health equity. For example, targeted campaigns promoting tobacco cessation combined with culturally tailored interventions for SMP may be one solution to reduce chronic diseases among SMP. Or, if excess stress is thought to drive health disparities among SMP—as stated by predominant theory—stress-reducing interventions may also be another strategy that could contribute to reducing chronic diseases. It must be cautioned, however, that the development, testing, and implementation of individual-level behavioral interventions should not negate the urgency for disease prevention at all other socioecological levels. Rather, behavioral-level interventions

should be one component of a comprehensive, multilevel strategy to promote health equity and reduce chronic disease disparities among SMP.

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Appendix. Figures and Tables

Table 3.1 Unweighted sample characteristics, by self-reported sexual orientation: National Health and Nutrition Examination Survey, 2009-2014

	Sexual Identity				Lifetime Sexual Behavior				12-Month Sexual Behavior				Lifetime Sexual Behavior + Sexual Identity			
	Heterosexual	Lesbian/Gay	Bisexual		Heterosexual	Lesbian/Gay	Bisexual		Heterosexual	Lesbian/Gay	Bisexual		Self-identified heterosexual with history of only opposite sex sexual behavior	Self-identified SMP with history of same-sex sexual behavior	Self-identified heterosexual with history of same-sex sexual behavior	
	n (%)			X2/t	n (%)			X2/t	n (%)			X2/t	(n (%)			X2/t
Women																
Total	4446 (93.9)	63 (1.3)	225 (4.8)		4215 (89.6)	16 (0.3)	473 (10.1)		3885 (96.0)	58 (1.4)	104 (2.6)		4053 (89.8)	232 (5.1)	228 (5.0)	
Race/Ethnicity				34.8 ***				45.5 ***				39.0 ***				
White, non-Hispanic	1860 (41.8)	30 (47.6)	107 (47.6)		1737 (41.2)	6 (37.5)	222 (46.9)		1700 (42.1)	41 (42.7)	11 (45.8)		1690 (41.7)	109 (47.0)	112 (49.1)	42.5 ***
Black, non-Hispanic	937 (21.1)	22 (34.9)	60 (26.7)		882 (20.9)	5 (31.2)	137 (29.0)		855 (21.2)	23 (24.0)	3 (12.5)		857 (21.1)	72 (31.0)	58 (25.4)	
Mexican American	657 (14.8)	5 (7.9)	14 (6.2)		633 (15.0)	3 (18.8)	36 (7.6)		618 (15.3)	11 (11.5)	5 (20.8)		600 (14.8)	21 (9.0)	21 (9.2)	
Other Hispanic	479 (10.8)	2 (3.2)	16 (7.1)		458 (10.9)	1 (6.2)	32 (6.8)		380 (9.4)	11 (11.5)	4 (16.7)		443 (10.9)	14 (6.0)	21 (9.2)	
Other	513 (11.5)	4 (6.4)	28 (12.4)		505 (12.0)	1 (6.2)	46 (9.7)		488 (12.1)	10 (10.4)	1 (4.2)		463 (11.4)	16 (7.0)	16 (7.0)	
Age				96.1 ***				63.7 ***				54.4 ***				71.1 ***
20-29	1094 (24.6)	21 (33.3)	119 (52.9)		987 (23.4)	8 (50.0)	179 (37.8)		1042 (26.8)	25 (43.1)	60 (57.7)		943 (23.3)	107 (46.1)	69 (30.3)	
30-39	1087 (24.4)	13 (20.6)	52 (23.1)		1036 (24.6)	1 (6.2)	124 (26.2)		1060 (27.3)	11 (19.0)	23 (22.1)		1006 (24.8)	54 (23.3)	65 (28.5)	
40-49	1196 (26.9)	14 (22.2)	36 (16.0)		1147 (27.2)	3 (18.8)	97 (20.5)		1068 (27.5)	12 (20.7)	15 (14.4)		1112 (27.4)	44 (19.0)	52 (22.8)	
50-59	1069 (24.0)	15 (23.8)	18 (8.0)		1045 (24.8)	4 (25.0)	73 (15.4)		715 (18.4)	10 (17.2)	6 (5.8)		992 (24.5)	27 (11.6)	42 (18.4)	

Table 3.1 continued

	Sexual Identity				Lifetime Sexual Behavior				12-Month Sexual Behavior				Lifetime Sexual Behavior + Sexual Identity			
	Heterosexual	Lesbian/Gay	Bisexual		Heterosexual	Lesbian/Gay	Bisexual		Heterosexual	Lesbian/Gay	Bisexual		Self-identified heterosexual with history of only opposite sex sexual behavior	Self-identified SMP with history of same-sex sexual behavior	Self-identified heterosexual with history of same-sex sexual behavior	
	n (%)			X2/t	n (%)			X2/t	n (%)			X2/t	n (%)			X2/t
Educational Level				17.4 **				19.4 **				17.07 **				20.8 **
< High school	808 (18.2)	13 (20.6)	40 (17.8)		794 (18.8)	5 (31.2)	74 (15.6)		712 (18.3)	11 (19.0)	23 (22.1)		732 (18.1)	42 (18.1)	32 (14.0)	
High school/ GED	855 (19.2)	12 (19.0)	53 (23.6)		829 (19.7)	5 (31.2)	100 (21.1)		770 (19.8)	14 (24.1)	29 (27.9)		798 (19.7)	55 (23.7)	39 (17.1)	
Some college/AA degree	1552 (34.9)	19 (30.2)	95 (42.2)		1435 (34.0)	3 (18.8)	197 (41.6)		1338 (34.4)	20 (34.5)	40 (38.5)		1392 (34.3)	88 (37.9)	106 (46.5)	
≥ College graduate	1231 (27.7)	19 (30.2)	37 (16.4)		1157 (27.4)	3 (18.8)	102 (21.6)		1065 (27.4)	13 (22.4)	12 (11.5)		1131 (27.9)	47 (20.3)	51 (22.4)	
Marital Status				158.0 ***				167.8 ***				166.8 ***				167.5 ***
Married	2182 (49.1)	2 (3.2)	55 (24.4)		2150 (51.0)	0 (0.0)	120 (25.4)		2103 (54.1)	2 (3.4)	15 (14.4)		2072 (51.1)	40 (17.2)	75 (32.9)	
Widowed	84 (1.9)	0 (0.0)	3 (1.3)		78 (1.8)	0 (0.0)	10 (2.1)		44 (1.1)	2 (3.4)	1 (1.0)		74 (1.8)	3 (1.3)	7 (3.1)	
Divorced	519 (11.7)	5 (7.9)	27 (12.0)		486 (11.5)	0 (0.0)	74 (15.6)		343 (8.8)	7 (12.1)	12 (11.5)		471 (11.6)	26 (11.2)	41 (18.0)	
Separated	193 (4.3)	1 (1.6)	6 (2.7)		190 (4.5)	1 (6.3)	14 (3.0)		144 (3.7)	0 (0.0)	6 (5.8)		178 (4.4)	6 (2.6)	9 (4.0)	
Never married	1037 (23.3)	37 (58.7)	100 (44.4)		901 (12.4)	11 (68.8)	185 (39.1)		814 (21.0)	29 (50.0)	59 (56.7)		864 (21.3)	114 (49.1)	68 (29.8)	
Living with partner	429 (9.6)	18 (28.6)	34 (15.1)		408 (9.7)	4 (25.0)	70 (14.8)		436 (11.2)	18 (31.0)	11 (10.6)		392 (9.7)	43 (18.5)	28 (12.3)	
Obese	1808 (40.7)	28 (44.4)	106 (47.1)	3.9	1694 (40.2)	5 (31.2)	233 (49.3)	14.9 **	1520 (39.1)	25 (43.1)	53 (51.0)	6.1 *	1624 (40.1)	112 (48.3)	112 (49.1)	12.6 **
Current Smoker	893 (20.1)	30 (47.6)	107 (47.6)	100.9 ***	823 (19.5)	9 (56.2)	214 (45.2)	149.4 ***	815 (21.0)	26 (44.8)	58 (55.8)	72.8 ***	790 (19.5)	119 (51.3)	91 (39.9)	147.2 ***

Table 3.1 continued

	Sexual Identity				Lifetime Sexual Behavior				12-month Sexual Behavior				Lifetime Sexual Behavior + Sexual Identity			
	Heterosexual	Lesbian/Gay	Bisexual		Heterosexual	Lesbian/Gay	Bisexual		Heterosexual	Lesbian/Gay	Bisexual		Self-identified heterosexual with history of only opposite sex sexual behavior	Self-identified SMP with history of same-sex sexual behavior	Self-identified heterosexual with history of same-sex sexual behavior	
	n (%)			X2/t	n (%)			X2/t	n (%)			X2/t	n (%)			X2/t
Men																
Total	4606 (96.6)	93 (2.0)	69 (1.4)		4366 (94.7)	58 (1.3)	185 (4.0)		4041 (97.1)	96 (2.3)	24 (0.6)		4279 (94.9)	135 (3.0)	95 (2.1)	
Race/Ethnicity				5.6				19.4 *				6.2				14.8
White, non-Hispanic	1933 (42.0)	44 (47.3)	34 (49.3)		1835 (42.0)	7 (12.1)	18 (9.7)		898 (46.1)	23 (42.6)	7 (41.2)		1816 (42.4)	68 (50.4)	50 (52.6)	
Black, non-Hispanic	949 (20.6)	21 (22.6)	16 (23.2)		908 (20.8)	5 (8.6)	19 (10.3)		392 (20.1)	11 (20.4)	2 (11.8)		890 (20.8)	31 (23.0)	18 (19.0)	
Mexican American	723 (15.7)	10 (10.8)	8 (11.6)		684 (15.7)	25 (43.1)	98 (53.0)		277 (14.2)	6 (11.1)	3 (17.6)		667 (15.6)	14 (10.4)	11 (11.6)	
Other Hispanic	417 (9.0)	8 (8.6)	5 (7.2)		401 (9.2)	12 (20.7)	40 (21.6)		172 (8.8)	9 (16.7)	4 (23.5)		385 (9.0)	10 (7.4)	11 (11.6)	
Other	584 (12.7)	10 (10.8)	6 (8.7)		538 (12.3)	9 (15.5)	10 (5.4)		208 (10.7)	5 (0.3)	1 (5.9)		521 (12.2)	12 (8.9)	5 (5.3)	
Age				13.6 *				19.8 **				14.2 *				13.6 *
20-29	1204 (26.1)	32 (34.4)	21 (30.4)		1081 (24.8)	26 (44.8)	33 (17.8)		1023 (25.3)	35 (36.5)	6 (25.0)		1065 (24.9)	43 (31.8)	15 (15.8)	
30-39	1189 (25.8)	29 (31.2)	14 (20.3)		1137 (26.0)	15 (25.9)	55 (29.7)		1102 (27.3)	32 (33.3)	9 (37.5)		1125 (26.3)	40 (29.6)	27 (28.4)	
40-49	1135 (24.6)	10 (10.8)	18 (26.1)		1099 (25.2)	7 (12.1)	45 (24.3)		1041 (25.8)	14 (14.6)	6 (25.0)		1077 (25.2)	21 (15.6)	29 (30.5)	
50-59	1078 (23.4)	22 (23.7)	16 (23.2)		1049 (24.0)	10 (17.2)	52 (28.1)		875 (21.6)	15 (15.6)	3 (12.5)		1012 (23.6)	31 (23.0)	24 (25.3)	

Table 3.1 continued

	Sexual Identity				Lifetime Sexual Behavior				12-month Sexual Behavior				Lifetime Sexual Behavior + Sexual Identity			
	Heterosexual	Lesbian/Gay	Bisexual		Heterosexual	Lesbian/Gay	Bisexual		Heterosexual	Lesbian/Gay	Bisexual		Self-identified heterosexual with history of only opposite sex sexual behavior	Self-identified SMP with history of same-sex sexual behavior	Self-identified heterosexual with history of same-sex sexual behavior	
	n (%)			X2/t	n (%)			X2/t	n (%)			X2/t	n (%)			X2/t
Educational Level				31.2 ***				24.1 ***				23.4 ***				24.9 ***
< High school	994 (21.6)	6 (6.4)	8 (11.6)		955 (21.9)	8 (13.8)	19 (10.3)		852 (21.1)	7 (7.3)	5 (20.8)		915 (21.4)	10 (7.4)	13 (13.7)	
High school/ GED	1115 (24.2)	19 (20.4)	23 (33.3)		1068 (24.5)	11 (19.0)	49 (26.5)		978 (24.2)	21 (21.9)	7 (29.2)		1050 (24.5)	34 (25.2)	24 (25.3)	
Some college/AA degree	1371 (29.8)	30 (32.3)	26 (37.7)		1279 (29.3)	16 (27.6)	65 (35.1)		1202 (29.8)	30 (31.2)	10 (41.7)		1263 (29.5)	44 (32.6)	32 (33.7)	
≥ College graduate	1126 (24.4)	38 (40.9)	12 (17.4)		1064 (24.4)	23 (39.7)	52 (28.1)		1009 (25.0)	38 (39.6)	2 (8.3)		1051 (24.6)	47 (34.8)	26 (27.4)	
Marital Status				143.4 ***				133.0 ***				134.2 ***				122.3 ***
Married	2334 (50.7)	3 (3.2)	23 (33.3)		2283 (52.3)	2 (3.4)	60 (32.4)		2207 (54.6)	4 (4.2)	8 (33.3)		2241 (52.4)	17 (12.6)	41 (43.2)	
Widowed	30 (0.6)	0 (0.0)	0 (0.0)		34 (0.8)	0 (0.0)	1 (0.5)		22 (0.5)	0 (0.0)	0 (0.0)		30 (0.7)	0 (0.0)	0 (0.0)	
Divorced	388 (8.4)	3 (3.2)	9 (13.0)		369 (8.4)	0 (0.0)	29 (15.7)		307 (7.6)	7 (7.3)	2 (8.3)		362 (8.5)	10 (7.4)	17 (17.9)	
Separated	138 (3.0)	2 (2.2)	1 (1.4)		134 (3.1)	0 (0.0)	9 (4.9)		113 (2.8)	2 (2.1)	1 (4.2)		129 (3.0)	3 (2.2)	5 (5.3)	
Never married	1230 (26.7)	60 (64.5)	32 (46.4)		1076 (24.6)	44 (75.9)	59 (31.9)		924 (22.9)	61 (63.5)	9 (37.5)		1055 (24.7)	78 (57.8)	20 (21.0)	
Living with partner	484 (10.5)	25 (26.9)	4 (5.8)		468 (10.7)	12 (20.7)	27 (14.6)		466 (11.5)	22 (22.9)	4 (16.7)		460 (10.8)	27 (20.0)	12 (12.6)	
Obese	1584 (34.4)	19 (20.4)	23 (33.3)	8.6 *	1499 (34.3)	13 (22.4)	56 (30.3)	5.1	1386 (34.3)	21 (21.9)	4 (16.7)	10.5 **	1477 (34.5)	33 (24.4)	31 (32.6)	6.3 *
Current smoker	1283 (27.8)	32 (34.4)	25 (36.2)	4.04	1238 (28.4)	16 (27.6)	70 (37.8)	7.4 *	1148 (28.4)	35 (36.5)	10 (41.7)	4.7	1214 (28.4)	49 (36.3)	31 (32.6)	4.6

*p < .05 **p < .01 ***p ≤ .001

Table 3.2 Unadjusted, weighted prevalence of self-reported chronic disease stratified by gender and sexual orientation: National Health and Nutrition Examination Survey, 2009-2014

	Heterosexual	Sexual Minority			Heterosexual	Lesbian/ Gay	Bisexual		
	% (SE)		X2	p	% (SE)			X2	p
Women									
Sexual Identity									
	(n = 4440)	(n = 288)			(n = 4440)	(n = 63)	(n = 225)		
Arthritis	19.0 (0.9)	21.4 (2.9)	3.1	0.43	19.0 (0.9)	28.5 (5.9)	19.3 (3.4)	10.7	0.32
Asthma	**17.0 (0.7)**	**34.1 (4.3)**	**144.3**	**≤.001**	**17.0 (0.7)**	**43.2 (9.9)**	**31.4 (4.0)**	**153.9**	**≤.001**
Cancer	7.2 (0.7)	5.0 (1.4)	6.6	0.24	7.2 (0.7)	2.9 (1.7)	5.6 (1.7)	9.3	0.26
Chronic Bronchitis	**6.5 (0.5)**	**10.4 (1.5)**	**18.2**	**0.008**	**6.6 (0.5)**	**18.0 (5.1)**	**8.2 (1.9)**	**33.0**	**0.02**
Diabetes	5.9 (0.4)	3.9 (1.2)	7.0	0.14	5.9 (0.4)	3.9 (2.4)	3.9 (1.4)	7.0	0.35
Heart Attack	1.2 (0.2)	0.4 (0.3)	5.7	0.13	1.2 (0.2)	0 (0.0)	0.5 (0.4)	-[a]	-[a]
Hypertension	**22.4 (0.8)**	**15.3 (2.3)**	**26.6**	**0.009**	**22.4 (0.8)**	**14.0 (4.0)**	**15.7 (2.8)**	**27.0**	**0.03**
Lifetime Sexual Behavior									
	(n = 4212)	(n = 489)			(n = 4212)	(n = 16)	(n = 473)		
Arthritis	19.7 (1.0)	18.4 (2.0)	1.4	0.60	19.7 (1.0)	22.7 (9.6)	18.3 (2.1)	1.7	0.70
Asthma	**16.8 (0.7)**	**28.9 (3.1)**	**121.2**	**≤.001**	**16.8 (0.7)**	**27.8 (9.4)**	**28.9 (3.1)**	**121.2**	**≤.001**
Cancer	7.0 (0.7)	6.6 (1.2)	0.5	0.74	7.0 (0.7)	6.2 (6.0)	6.6 (1.3)	0.5	0.89
Chronic Bronchitis	**6.6 (0.5)**	**9.5 (1.3)**	**17.1**	**0.02**	**6.6 (0.5)**	**10.2 (7.4)**	**9.5 (1.3)**	**17.1**	**0.04**
Diabetes	**6.0 (0.4)**	**3.4 (0.8)**	**19.4**	**0.02**	**6.0 (0.4)**	**3.7 (3.7)**	**3.4 (0.9)**	**19.4**	**0.03**
Heart Attack	1.2 (0.2)	0.6 (0.3)	4.9	0.19	1.2 (0.2)	0 (0)	0.6 (0.3)	-[a]	-[a]
Hypertension	**22.6 (0.8)**	**17.7 (2.0)**	**19.8**	**0.04**	**22.6 (0.8)**	**3.7 (3.7)**	**18.0 (2.1)**	**25.2**	**0.02**
12 month Sexual Behavior									
	(n = 3881)	(n = 162)			(n = 3881)	(n = 58)	(n = 104)		
Arthritis	16.9 (0.8)	18.9 (3.6)	1.5	0.58	16.9 (0.8)	26.7 (5.8)	13.3 (4.1)	16.6	0.16
Asthma	**16.9 (0.7)**	**34.4 (5.4)**	**91.3**	**≤.001**	**16.9 (0.7)**	**40.5 (9.0)**	**30.0 (5.4)**	**97.6**	**≤.001**
Cancer	6.4 (0.7)	5.4 (1.8)	1.0	0.63	6.4 (0.7)	2.6 (1.9)	7.3 (2.9)	7.1	0.40
Chronic Bronchitis	6.3 (0.5)	8.2 (1.5)	2.8	0.15	6.3 (0.5)	11.3 (3.6)	6.0 (2.3)	7.7	0.25
Diabetes	4.9 (0.4)	2.3 (1.1)	8.8	0.10	4.9 (0.4)	3.3 (2.2)	1.6 (1.2)	10.4	0.18
Heart Attack	0.9 (0.2)	0.9 (0.7)	0.0	0.96	0.9 (0.2)	1.4 (1.4)	0.5 (0.6)	1.0	0.81
Hypertension	**19.8 (0.8)**	**11.4 (2.7)**	**26.2**	**0.01**	**19.8 (0.8)**	**9.2 (4.1)**	**13.0 (3.4)**	**28.1**	**0.03**

Table 3.2 continued

Lifetime Sexual Behavior + Sexual Identity					Self-identified heterosexual with history of only opposite-sex sexual behavior	Self-identified SMP with history of same-sex sexual behavior	Self-identified heterosexual with history of same-sex sexual behavior		
						% (SE)		X2	p
					(n =1355)	(n=153)	(n=147)		
Arthritis					19.6 (1.0)	21.9 (3.3)	14.8 (2.5)	14.1	0.22
Asthma					**16.7 (0.7)**	**37.1 (5.0)**	**21.7 (2.8)**	**173.9**	**≤.001**
Cancer					7.1 (0.7)	5.1 (1.7)	8.1 (2.0)	6.0	0.52
Chronic Bronchitis					**6.5 (0.5)**	**10.4 (1.7)**	**9.1 (1.7)**	**20.3**	**0.03**
Diabetes					**6.0 (0.4)**	**4.3 (1.3)**	**2.8 (0.9)**	**19.0**	**0.05**
Heart Attack					1.2 (0.3)	0.5 (0.4)	0.3 (0.3)	9.9	0.16
Hypertension					22.6 (0.8)	16.1 (2.7)	19.9 (3.3)	20.8	0.11
Men									
Sexual Identity									
	(n = 4600)	(n = 162)			(n = 4600)	(n = 93)	(n = 69)		
Arthritis	12.7 (0.6)	18.8 (4.7)	17.8	0.15	12.7 (0.6)	16.2 (4.9)	23.8 (8.3)	22.9	0.21
Asthma	12.8 (0.6)	15.4 (3.8)	3.4	0.48	12.8 (0.6)	16.6 (4.6)	13.2 (5.2)	4.6	0.64
Cancer	3.9 (0.5)	6.6 (2.7)	9.6	0.27	3.9 (0.5)	8.1 (3.7)	3.7 (2.9)	14.3	0.3
Chronic Bronchitis	**2.7 (0.3)**	**8.9 (3.9)**	**52.0**	**0.02**	**2.7 (0.3)**	**12.1 (5.8)**	**3.0 (1.4)**	**68.2**	**0.02**
Diabetes	5.5 (0.5)	5.2 (2.1)	0.1	0.89	5.5 (0.5)	3.6 (2.3)	8.1 (3.8)	5.4	0.60
Heart Attack	1.5 (0.2)	3.8 (2.3)	14.1	0.25	1.5 (0.2)	5.8 (3.4)	0 (0)	-[a]	-[a]
Hypertension	24.0 (0.9)	25.5 (4.6)	0.7	0.75	24.0 (0.9)	21.4 (4.6)	33.1 (9.3)	10.6	0.46
Lifetime Sexual Behavior									
	(n = 4360)	(n = 243)			(n = 4360)	(n = 58)	(n = 185)		
Arthritis	13.2 (0.6)	16.2 (3.5)	6.5	0.34	13.2 (0.6)	15.1 (7.0)	16.6 (4.2)	6.8	0.65
Asthma	**12.4 (0.7**	**18.6 (3.0)**	**26.6**	**0.04**	**12.4 (0.7)**	**12.3 (4.4)**	**20.5 (3.9)**	**34.4**	**0.05**
Cancer	4.1 (0.5)	4.4 (1.9)	0.3	0.84	4.1 (0.5)	5.0 (4.1)	4.3 (2.0)	0.5	0.96
Chronic Bronchitis	2.9 (0.3)	6.8 (2.9)	34.5	0.08	2.9 (0.3)	5.2 (4.1)	7.3 (2.7)	35.7	0.10
Diabetes	5.6 (0.5)	4.4 (1.4)	2.6	0.49	5.6 (0.5)	6.7 (4.4)	3.6 (1.3)	6.1	0.55
Heart Attack	1.6 (0.2)	2.8 (1.7)	7.0	0.42	1.6 (0.2)	6.2 (5.9)	1.8 (1.4)	16.6	0.45
Hypertension	24.1 (0.9)	27.2 (3.7)	4.4	0.39	24.1 (0.9)	32.5 (7.0)	25.5 (4.4)	8.4	0.48

Table 3.2 continued

	Heterosexual	Sexual Minority			Heterosexual	Lesbian/ Gay	Bisexual		
	% (SE)		X2	p		% (SE)		X2	p
12 month Sexual Behavior									
	(n = 4036)	(n = 120)			(n = 4036)	(n = 96)	(n = 24)		
Arthritis	12.9 (0.7)	13.5 (4.6)	0.2	0.88	12.9 (0.7)	14.8 (5.3)	6.3 (4.4)	4.8	0.58
Asthma	12.8 (0.7)	13.0 (3.7)	0.0	0.97	12.8 (0.7)	14.2 (4.3)	5.8 (2.8)	4.8	0.47
Cancer	3.6 (0.4)	5.3 (3.0)	3.6	0.52	3.6 (0.4)	6.2 (3.5)	0 (0)	-[a]	-[a]
Chronic Bronchitis	**2.8 (.3)**	**8.0 (3.5)**	**32.3**	**0.04**	2.8 (0.3)	8.4 (3.8)	5.7 (6.0)	33.1	0.08
Diabetes	5.1 (0.5)	4.3 (2.4)	0.8	0.74	5.1 (0.5)	4.5 (2.8)	3.0 (2.9)	1.2	0.84
Heart Attack	1.4 (0.2)	3.3 (2.0)	8.9	0.27	1.4 (0.2)	3.8 (2.4)	0 (0)	-[a]	-[a]
Hypertension	23.3 (1.0)	23.2 (5.0)	0.0	0.98	23.3 (1.0)	25.9 (5.5)	8.0 (6.4)	14.1	0.27
Lifetime Sexual Behavior + Sexual Identity									
					Self-identified heterosexual with history of only opposite-sex sexual behavior	Self-identified SMP with history of same-sex sexual behavior	Self-identified heterosexual with history of same-sex sexual behavior		
						% (SE)		X2	p
					(n = 4273)	(n = 135)	(n = 95)		
Arthritis					13.2 (0.6)	19.4 (5.1)	7.6 (2.5)	27.1	0.10
Asthma					12.4 (0.7)	14.6 (4.0)	23.4 (5.6)	31.7	0.10
Cancer					4.1 (0.5)	7.5 (3.1)	0 (0)	-[a]	-[a]
Chronic Bronchitis					**2.8 (0.3)**	**10.2 (4.4)**	**2.2 (1.5)**	**62.0**	**0.02**
Diabetes					5.6 (0.5)	4.7 (2.2)	3.1 (1.4)	5.1	0.53
Heart Attack					1.6 (0.2)	4.0 (2.6)	1.3 (0.8)	14.1	0.31
Hypertension					24.1 (1.0)	25.6 (4.7)	32.3 (5.7)	11.5	0.36

[a] Parameter not estimated.

Table 3.3 Self-reported chronic diseases among sexual minority women by sexual orientation measurement: National Health and Nutrition Examination Survey, 2009-2014

	Model 1 Adjusted for demographic variables	**Model 2** Adjusted for demographic variables and current smoking	**Model 3** Adjusted for demographic variables, current smoking, and obesity
	aOR (95% CI)		
Arthritis			
Sexual Identity			
Sexual minority	**2.13 (1.35, 3.36)**	**1.92 (1.20, 3.08)**	**1.79 (1.12, 2.86)**
Lesbian	**2.27 (1.15, 4.48)**	**2.00 (1.02, 3.91)**	1.88 (0.93, 3.82)
Bisexual	**2.07 (1.18, 3.66)**	**1.89 (1.05, 3.40)**	1.76 (1.00, 3.07)
Lifetime Sexual Behavior			
Sexual minority	1.34 (0.94, 1.90)	1.91 (0.82, 1.73)	1.10 (0.75, 1.61)
Lesbian	2.01 (0.50, 8.07)	1.59 (0.36, 7.13)	1.78 (0.49, 6.54)
Bisexual	1.33 (0.92, 1.91)	1.18 (0.80, 1.74)	1.09 (0.74, 1.61)
12 month Sexual Behavior			
Sexual minority	1.79 (0.97, 3.32)	1.60 (0.86, 2.97)	1.50 (0.82, 2.74)
Lesbian	1.98 (0.87, 4.51)	1.88 (0.86, 4.09)	1.83 (0.87, 3.83)
Bisexual	1.60 (0.72, 3.55)	1.32 (0.57, 3.07)	1.21 (0.52, 2.84)
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	**2.08 (1.28, 3.36)**	**1.83 (1.11, 3.00)**	**1.67 (1.02, 2.74)**
Self-identified heterosexual with history of same-sex sexual behavior	0.85 (0.52, 1.37)	0.75 (0.45, 1.25)	0.70 (0.42, 1.16)
Asthma			
Sexual Identity			
Sexual minority	**2.37 (1.59, 3.51)**	**2.10 (1.39, 3.18)**	**1.98 (1.32, 2.98)**
Lesbian	**3.75 (1.62, 8.66)**	**3.27 (1.41, 7.61)**	**3.19 (1.37, 7.47)**
Bisexual	**2.04 (1.39, 3.00)**	**1.82 (1.20, 2.76)**	**1.70 (1.12, 2.58)**
Lifetime Sexual Behavior			
Sexual minority	**1.90 (1.40, 2.57)**	**1.68 (1.22, 2.33)**	**1.60 (1.16, 2.21)**
Lesbian	1.91 (0.72, 5.07)	1.59 (0.59, 4.27)	1.68 (0.62, 4.55)
Bisexual	**1.90 (1.40, 2.57)**	**1.69 (1.22, 2.33)**	**1.60 (1.16, 2.20)**
12 month Sexual Behavior			
Sexual minority	**2.37 (1.43, 3.91)**	**2.06 (1.23, 3.44)**	**1.96 (1.16, 3.31)**
Lesbian	**3.27 (1.50, 7.14)**	**3.01 (1.34, 6.75)**	**3.01 (1.31, 6.91)**
Bisexual	**1.84 (1.07, 3.15)**	1.53 (0.87, 2.70)	1.42 (0.79, 2.57)

Table 3.3 continued

	Model 1 Adjusted for demographic variables	Model 2 Adjusted for demographic variables and current smoking	Model 3 Adjusted for demographic variables, current smoking, and obesity
	aOR (95% CI)		
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	**2.80 (1.81, 4.34)**	**2.46 (1.55, 3.90)**	**2.30 (1.45, 3.65)**
Self-identified heterosexual with history of same-sex sexual behavior	1.30 (0.93, 1.83)	1.18 (0.83, 1.70)	1.14 (0.80, 1.63)
Cancer			
Sexual Identity			
Sexual minority	0.96 (0.48, 1.92)	0.88 (0.45, 1.74)	0.84 (0.42, 1.67)
Lesbian	0.40 (0.11, 1.41)	0.35 (0.10, 1.30)	0.34 (0.09, 1.29)
Bisexual	1.22 (0.59, 2.54)	1.13 (0.56, 2.30)	1.08 (0.53, 2.19)
Lifetime Sexual Behavior			
Sexual minority	1.16 (0.69, 1.94)	1.04 (0.62, 1.74)	1.00 (0.60, 1.68)
Lesbian	1.63 (0.20, 13.32)	1.34 (0.17, 10.76)	1.39 (0.17, 11.44)
Bisexual	1.15 (0.68, 1.94)	1.03 (0.61, 1.75)	0.99 (0.59, 1.68)
12 month Sexual Behavior			
Sexual minority	1.16 (0.48, 2.76)	1.07 (0.46, 2.46)	1.04 (0.45, 2.40)
Lesbian	0.37 (0.08, 1.70)	0.36 (0.08, 1.66)	0.36 (0.08, 1.65)
Bisexual	2.47 (0.97, 6.30)	2.10 (0.82, 5.38)	2.02 (0.77, 5.28)
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	0.97 (0.43, 2.19)	0.88 (0.39, 1.95)	0.83 (0.37, 1.85)
Self-identified heterosexual with history of same-sex sexual behavior	1.29 (0.70, 2.37)	1.16 (0.62, 2.17)	1.13 (0.60, 2.12)

Table 3.3 continued

	Model 1	Model 2	Model 3
	Adjusted for demographic variables	Adjusted for demographic variables and current smoking	Adjusted for demographic variables, current smoking, and obesity
	aOR (95% CI)		
Chronic Bronchitis			
Sexual Identity			
Sexual minority	**1.80 (1.25, 2.60)**	1.48 (1.00, 2.20)	1.38 (0.92, 2.06)
Lesbian	**3.50 (1.65, 7.42)**	**2.80 (1.34, 5.83)**	**2.64 (1.21, 5.72)**
Bisexual	1.36 (0.82, 2.26)	1.12 (0.65, 1.93)	1.05 (0.60, 1.81)
Lifetime Sexual Behavior			
Sexual minority	**1.59 (1.13, 2.24)**	1.28 (0.91, 1.80)	1.20 (0.87, 1.67)
Lesbian	1.83 (0.32, 10.49)	1.22 (0.21, 7.02)	1.29 (0.21, 7.83)
Bisexual	1.58 (1.13, 2.22)	1.28 (0.91, 1.80)	1.20 (0.87, 1.66)
12 month Sexual Behavior			
Sexual minority	1.32 (0.88, 1.98)	1.05 (0.70, 1.59)	1.01 (0.67, 1.53)
Lesbian	1.82 (0.84, 3.96)	1.60 (0.76, 3.36)	1.55 (0.72, 3.30)
Bisexual	0.95 (0.43, 2.09)	0.71 (0.33, 1.53)	0.68 (0.31, 1.47)
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	**1.83 (1.22, 2.73)**	1.45 (0.96, 2.20)	1.33 (0.88, 2.02)
Self-identified heterosexual with history of same-sex sexual behavior	1.48 (0.91, 2.43)	1.23 (0.75, 2.00)	1.18 (0.74, 1.87)
Diabetes			
Sexual Identity			
Sexual minority	1.10 (0.57, 2.12)	1.11 (0.57, 2.17)	0.97 (0.50, 1.89)
Lesbian	0.84 (0.22, 3.27)	0.79 (0.21, 2.91)	0.79 (0.21, 2.91)
Bisexual	1.23 (0.54, 2.80)	1.04 (0.45, 2.40)	1.04 (0.45, 2.40)
Lifetime Sexual Behavior			
Sexual minority	0.78 (0.46, 1.33)	0.80 (0.46, 1.38)	0.67 (0.38, 1.18)
Lesbian	0.60 (0.06, 6.44)	0.63 (0.06, 6.95)	0.91 (0.08, 10.61)
Bisexual	0.79 (0.46, 1.35)	0.81 (0.47, 1.40)	0.67 (0.38, 1.18)
12 month Sexual Behavior			
Sexual minority	0.64 (0.24, 1.74)	0.64 (0.24, 1.74)	0.57 (0.21, 1.50)
Lesbian	0.80 (0.20, 3.22)	0.80 (0.20, 3.22)	0.79 (0.20, 3.12)
Bisexual	0.50 (0.12, 2.03)	0.50 (0.12, 2.03)	0.40 (0.10, 1.62)
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	1.21 (0.60, 2.43)	1.23 (0.60, 2.54)	1.04 (0.51, 2.15)
Self-identified heterosexual with history of same-sex sexual behavior	0.56 (0.27, 1.16)	0.57 (0.27, 1.19)	0.48 (0.23, 1.01)

Table 3.3 continued

	Model 1 Adjusted for demographic variables	Model 2 Adjusted for demographic variables and current smoking	Model 3 Adjusted for demographic variables, current smoking, and obesity
	aOR (95% CI)		
Heart Attack			
Sexual Identity			
Sexual minority	0.66 (0.12, 3.59)	0.58 (0.11, 3.08)	0.55 (0.10, 2.86)
Lesbian	-[a]	-[a]	-[a]
Bisexual	-[a]	-[a]	-[a]
Lifetime Sexual Behavior			
Sexual minority	0.80 (0.26, 2.48)	0.62 (0.19, 2.00)	0.57 (0.18, 1.83)
Lesbian	-[a]	-[a]	-[a]
Bisexual	-[a]	-[a]	-[a]
12 month Sexual Behavior			
Sexual minority	1.56 (0.30, 8.10)	1.29 (0.26, 6.40)	1.15 (0.23, 5.77)
Lesbian	1.86 (0.19, 17.79)	1.78 (0.21, 15.44)	1.51 (0.18, 12.68)
Bisexual	1.20 (0.16, 9.28)	0.84 (0.11, 6.62)	0.80 (0.09, 7.03)
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	0.82 (0.15, 4.65)	0.70 (0.13, 3.78)	0.64 (0.12, 3.41)
Self-identified heterosexual with history of same-sex sexual behavior	0.35 (0.03, 3.64)	0.26 (0.02, 2.97)	0.24 (0.02, 2.69)
Hypertension			
Sexual Identity			
Sexual minority	0.90 (0.58, 1.38)	0.88 (0.56, 1.36)	0.76 (0.50, 1.18)
Lesbian	0.60 (0.28, 1.29)	0.58 (0.27, 1.24)	0.51 (0.25, 1.02)
Bisexual	1.02 (0.61, 1.73)	1.00 (0.59, 1.69)	0.87 (0.50, 1.48)
Lifetime Sexual Behavior			
Sexual minority	0.92 (0.66, 1.28)	0.89 (0.63, 1.24)	0.77 (0.56, 1.06)
Lesbian	0.12 (0.01, 1.21)	0.10 (0.01, 1.14)	0.12 (0.01, 1.33)
Bisexual	0.94 (0.68, 1.32)	0.91 (0.65, 1.27)	0.78 (0.57, 1.08)
12 month Sexual Behavior			
Sexual minority	0.61 (0.34, 1.08)	0.58 (0.32, 1.04)	0.51 (0.29, 0.90)
Lesbian	0.38 (0.13, 1.12)	0.37 (0.13, 1.10)	0.34 (0.11, 1.01)
Bisexual	0.86 (0.46, 1.61)	0.81 (0.43, 1.52)	0.68 (0.35, 1.31)
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	0.93 (0.57, 1.50)	0 89 (0.55, 1.46)	0.89 (0.55, 1.46)
Self-identified heterosexual with history of same-sex sexual behavior	0.96 (0.59, 1.56)	0.93 (0.58, 1.51)	0.93 (0.58, 1.51)

aOR = adjusted odds ratio; CI = confidence interval. Nested multivariable regression analyses adjusted for race/ethnicity, education, age, current smoking, and obesity. Heterosexuals served as the referent group for analyses testing differences between 1. sexual minority women and heterosexual women, 2. lesbian, bisexual, and heterosexual women, and 3. homosexually-experienced self-identified sexual minority women, homosexually-experienced self-identified heterosexual women, and exclusively heterosexually experienced self-identified heterosexual women. Where a group reported zero prevalence for specific chronic diseases the entire group was excluded from analyses. [a] Parameter not estimated.

Table 3.4 Self-reported chronic diseases among sexual minority men by sexual orientation measurement: National Health and Nutrition Examination Survey, 2009-2014

	Model 1 Adjusted for demographic variables	**Model 2** Adjusted for demographic variables and current smoking	**Model 3** Adjusted for demographic variables, current smoking, and obesity
	aOR (95% CI)		
Arthritis			
Sexual Identity			
Sexual minority	1.62 (0.87, 3.00)	1.58 (0.85, 2.94)	1.60 (0.87, 2.96)
Homosexual	1.34 (0.63, 2.86)	1.29 (0.61, 2.70)	1.33 (0.64, 2.76)
Bisexual	2.14 (0.84, 5.46)	2.15 (0.84, 5.50)	2.13 (0.84, 5.40)
Lifetime Sexual Behavior			
Sexual minority	1.23 (0.76, 2.04)	1.22 (0.74, 2.01)	1.26 (0.76, 2.07)
Homosexual	1.73 (0.54, 5.60)	1.75 (0.54, 5.68)	1.84 (0.59, 5.77)
Bisexual	1.15 (0.65, 2.03)	1.12 (0.63, 1.99)	1.15 (0.64, 2.04)
12 month Sexual Behavior			
Sexual minority	1.20 (0.55, 2.60)	1.15 (0.52, 2.55)	1.20 (0.54, 2.67)
Homosexual	1.33 (0.57, 3.10)	1.27 (0.53, 3.03)	1.30 (0.54, 3.12)
Bisexual	0.55 (0.12, 2.44)	0.55 (0.12, 2.48)	0.62 (0.14, 2.79)
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	1.58 (0.82, 3.05)	1.54 (0.80, 2.98)	1.59 (0.83, 3.03)
Self-identified heterosexual with history of same-sex sexual behavior	0.54 (0.27, 1.05)	0.53 (0.27, 1.03)	0.55 (0.28, 1.06)
Asthma			
Sexual Identity			
Sexual minority	1.20 (0.63, 2.26)	1.18 (0.63, 2.23)	1.19 (0.63, 2.24)
Homosexual	1.30 (0.64, 2.64)	1.28 (0.63, 2.59)	1.29 (0.63, 2.61)
Bisexual	1.01 (0.39, 2.62)	1.01 (0.39, 2.62)	1.01 (0.39, 2.60)
Lifetime Sexual Behavior			
Sexual minority	**1.61 (1.02, 2.54)**	**1.59 (1.02, 2.48)**	**1.60 (1.03, 2.48)**
Homosexual	0.84 (0.38, 1.89)	0.84 (0.37, 1.89)	0.85 (0.38, 1.90)
Bisexual	**1.92 (1.12, 3.27)**	**1.89 (1.12, 3.19)**	**1.90 (1.12, 3.19)**
12 month Sexual Behavior			
Sexual minority	0.93 (0.48, 1.84)	0.92 (0.47, 1.82)	0.93 (0.47, 1.84)
Homosexual	1.03 (0.49, 2.14)	1.01 (0.48, 2.12)	1.02 (0.48, 2.14)
Bisexual	0.42 (0.15, 1.15)	0.42 (0.15, 1.14)	0.43 (0.16, 1.16)

Table 3.4 continued

	Model 1	Model 2	Model 3
	Adjusted for demographic variables	Adjusted for demographic variables and current smoking	Adjusted for demographic variables, current smoking, and obesity
		aOR (95% CI)	
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	1.17 (0.60, 2.31)	1.16 (0.59, 2.27)	1.16 (0.60, 2.28)
Self-identified heterosexual with history of same-sex sexual behavior	**2.22 (1.09, 4.52)**	**2.20 (1.09, 4.46)**	**2.21 (1.10, 4.46)**
Cancer			
Sexual Identity			
Sexual minority	1.50 (0.53, 4.26)	1.46 (0.51, 4.22)	1.47 (0.51, 4.26)
Homosexual	1.82 (.53, 6.21)	1.76 (0.51, 6.13)	1.76 (0.51, 6.12)
Bisexual	0.88 (0.14, 5.59)	0.88 (0.14, 5.54)	0.89 (0.14, 5.63)
Lifetime Sexual Behavior			
Sexual minority	0.90 (0.33, 2.48)	0.88 (0.32, 2.44)	0.88 (0.32, 2.43)
Homosexual	1.75 (0.17, 18.35)	1.80 (0.18, 18.26)	1.77 (0.17, 18.66)
Bisexual	0.76 (0.26, 2.25)	0.74 (0.25, 2.18)	0.74 (0.25, 2.16)
12 month Sexual Behavior			
Sexual minority	1.42 (0.40, 4.99)	1.37 (0.39, 4.83)	1.37 (0.39, 4.82)
Homosexual	-[a]	-[a]	-[a]
Bisexual	-[a]	-[a]	-[a]
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	-[a]	-[a]	-[a]
Self-identified heterosexual with history of same-sex sexual behavior	-[a]	-[a]	-[a]
Chronic Bronchitis			
Sexual Identity			
Sexual minority	**3.64 (1.49, 8.88)**	**3.18 (1.39, 7.26)**	**3.21 (1.44, 7.17)**
Homosexual	**5.65 (2.04, 15.70)**	**4.59 (1.81, 11.67)**	**4.68 (1.90, 11.56)**
Bisexual	0.99 (0.33, 3.00)	0.99 (0.34, 2.92)	0.99 (0.34, 2.91)
Lifetime Sexual Behavior			
Sexual minority	**2.59 (1.06, 6.31)**	**2.30 (1.01, 5.23)**	**2.32 (1.04, 5.20)**
Homosexual	2.12 (0.40, 11.13)	2.13 (0.42, 10.80)	2.17 (0.45, 10.49)
Bisexual	**2.72 (1.22, 6.06)**	**2.34 (1.12, 4.87)**	**2.36 (1.14, 4.89)**
12 month Sexual Behavior			
Sexual minority	**3.42 (1.32, 8.88)**	**2.96 (1.19, 7.38)**	**3.07 (1.24, 7.58)**
Homosexual	**3.74 (1.41, 9.93)**	**3.12 (1.21, 8.06)**	**3.22 (1.27, 8.20)**
Bisexual	2.00 (0.19, 21.48)	2.12 (0.21, 21.54)	2.23 (0.21, 23.43)

Table 3.4 continued

	Model 1	Model 2	Model 3
	Adjusted for demographic variables	Adjusted for demographic variables and current smoking	Adjusted for demographic variables, current smoking, and obesity
	aOR (95% CI)		
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	**4.10 (1.66, 10.16)**	**3.54 (1.53, 8.19)**	**3.60 (1.60, 8.09)**
Self-identified heterosexual with history of same-sex sexual behavior	0.80 (0.20, 3.24)	0.74 (0.18, 3.10)	0.75 (0.18, 3.18)
Diabetes			
Sexual Identity			
Sexual minority	0.96 (0.34, 2.70)	1.00 (0.36, 2.80)	1.06 (0.38, 2.95)
Homosexual	0.66 (0.13, 3.37)	0.69 (0.13, 3.60)	0.75 (0.15, 3.80)
Bisexual	1.58 (0.55, 4.58)	1.60 (0.57, 4.50)	1.64 (0.56, 4.78)
Lifetime Sexual Behavior			
Sexual minority	0.76 (0.31, 1.86)	0.79 (0.32, 1.93)	0.85 (0.35, 2.08)
Homosexual	1.95 (0.31, 12.34)	1.92 (0.30, 12.50)	2.19 (0.38, 12.54)
Bisexual	0.56 (0.24, 1.30)	0.58 (0.25, 1.33)	0.62 (0.26, 1.45)
12 month Sexual Behavior			
Sexual minority	1.09 (0.31, 3.82)	1.09 (0.31, 3.82)	1.24 (0.33, 4.61)
Homosexual	1.08 (0.27, 4.35)	1.17 (0.29, 4.72)	1.28 (0.30, 5.49)
Bisexual	0.69 (0.08, 5.64)	0.69 (0.08, 5.67)	1.01 (0.15, 6.97)
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	0.85 (0.26, 2.83)	0.89 (0.27, 2.98)	0.97 (0.29, 3.23)
Self-identified heterosexual with history of same-sex sexual behavior	0.54 (0.21, 1.36)	0.54 (0.21, 1.39)	0.57 (0.21, 1.50)
Heart Attack			
Sexual Identity			
Sexual minority	2.64 (0.4, 12.77)	2.46 (0.48, 12.47)	2.63 (0.52, 12.36)
Homosexual	-[a]	-[a]	-[a]
Bisexual	-[a]	-[a]	-[a]
Lifetime Sexual Behavior			
Sexual minority	1.92 (0.45, 8.10)	1.80 (0.42, 7.72)	1.91 (0.44, 8.33)
Homosexual	7.52 (0.81, 69.73)	8.12 (0.86, 76.78)	**9.40 (1.02, 86.27)**
Bisexual	1.06 (0.21, 5.42)	0.96 (0.19, 4.95)	1.01 (0.20, 5.18)
12 month Sexual Behavior			
Sexual minority	3.46 (0.71, 16.86)	3.20 (0.64, 16.00)	3.60 (0.74, 17.42)
Homosexual	-[a]	-[a]	-[a]
Bisexual	-[a]	-[a]	-[a]

Table 3.4 continued

	Model 1 Adjusted for demographic variables	Model 2 Adjusted for demographic variables and current smoking	Model 3 Adjusted for demographic variables, current smoking, and obesity
	aOR (95% CI)		
Hypertension			
Sexual Identity			
Sexual minority	1.08 (0.62, 1.88)	1.08 (0.62, 1.89)	1.12 (0.63, 1.99)
Homosexual	0.86 (0.42, 1.76)	0.86 (0.42, 1.77)	0.92 (0.43, 1.96)
Bisexual	1.52 (0.69, 3.36)	1.52 (0.69, 3.36)	1.52 (0.70, 3.27)
Lifetime Sexual Behavior			
Sexual minority	1.16 (0.73, 1.82)	1.15 (0.73, 1.82)	1.24 (0.78, 1.97)
Homosexual	**2.33 (1.24, 4.40)**	**2.33 (1.24, 4.40)**	**2.63 (1.40, 4.93)**
Bisexual	0.94 (0.55, 1.62)	0.94 (0.55, 1.61)	0.99 (0.58, 1.71)
12 month Sexual Behavior			
Sexual minority	1.13 (0.65, 1.96)	1.13 (0.65, 1.97)	1.25 (0.68, 2.30)
Homosexual	1.32 (0.74, 2.37)	1.32 (0.73, 2.39)	1.43 (0.75, 2.74)
Bisexual	0.32 (0.06, 1.87)	0.32 (0.06, 1.86)	0.42 (0.07, 2.51)
Sexual Behavior + Identity			
Self-identified SMP with history of same-sex sexual behavior	1.08 (0.60, 1.96)	1.08 (0.59, 1.96)	1.14 (0.62, 2.12)
Self-identified heterosexual with history of same-sex sexual behavior	1.53 (0.90, 2.58)	1.52 (0.90, 2.58)	1.66 (0.95, 2.90)

Note. aOR = adjusted odds ratio; CI = confidence interval. Nested multivariable regression analyses adjusted for race/ethnicity, education, age, current smoking, and obesity. Heterosexuals served as the referent group for analyses testing differences between 1. sexual minority men and heterosexual men, 2. gay, bisexual, and heterosexual men, and 3. homosexually-experienced self-identified sexual minority men, homosexually-experienced self-identified heterosexual men, and exclusively heterosexually experienced self-identified heterosexual men. Where a group reported zero prevalence for specific chronic diseases the entire group was excluded from analyses. [a] Parameter not estimated.

Chapter 4

Food Security and Cigarette Smoking in Diverse Subgroups of Sexual Minority Women and Men

Abstract

Purpose

To investigate associations between food insecurity and smoking in sexual minority women and men (SMW, SMM), using multiple measures of sexual orientation. To determine the extent of food insecurity disparities in diverse subgroups of SMW and SMM.

Methods

We pooled data from the 2005-2014 National Health and Nutrition Examination Survey to investigate associations between food insecurity and current smoking, nicotine dependence, and smoking intensity in SMW and SMM. We also investigated food insecurity disparities between heterosexual and sexual minority women and men. Sexual orientation was defined by sexual identity and in terms of sexual identity and sexual behavior (lifetime and 12 month). We used directed acyclic graphs (DAGs) to empirically inform covariate selection for all regression analyses.

Results

After controlling for DAG-identified covariates, gender-stratified analyses indicated that food insecure (vs. food secure) SMW were more likely to report current smoking, when sexual orientation was defined by sexual identity and lifetime sexual behavior (food insecure: aOR= 1.70; 95% CI, 1.11-2.59). When sexual orientation was defined by sexual identity and behavior, food insecure (vs. food secure; lifetime: aOR = 1.33; 95% CI, 1.07-1.66; 12-month: aOR = 1.82; 95% CI, 1.20-2.74) and severely food insecure (vs. food secure; lifetime: aOR = 1.29; 95% CI, 1.01-1.66; 12-month: aOR = 1.62; 95% CI, 1.05-2.51) SMW reported smoking more cigarettes per day. When sexual orientation was defined by sexual identity and lifetime sexual behavior, severely food insecure SMM (vs. food secure SMM) were more likely to report current smoking (aOR = 2.72; 95% CI, 1.01-7.29). When sexual orientation was defined by sexual identity, lesbian and bisexual women were more likely to report food insecurity (lesbian: aOR = 187; 95% CI, 1.10-1.39; bisexual aOR = 1.69; 95% CI, 1.15-2.51) and severe food insecurity (lesbian: aOR = 1.04; 95% CI, 1.01-3.73; bisexual: aOR = 1.86; 95% CI, 1.27-2.72) than heterosexual women. When sexual orientation was defined by sexual identity and lifetime sexual behavior, lesbians reporting same-sex sexual behavior (WSW), bisexual WSW, and heterosexual WSW were more likely to report food insecurity (lesbian WSW: aOR = 1.99; 95% CI, 1.10-3.61; bisexual WSW: aOR = 1.79; 95% CI, 1.19-2.68; heterosexual WSW: aOR = 1.56;

95% CI, 1.08-2.62) and severe food insecurity (lesbian WSW: aOR = 2.21; 95% CI, 1.11-4.40; bisexual WSW: aOR = 1.86; 95% CI, 1.29-2.87; heterosexual WSW: aOR = 2.01; 95% CI, 1.34-3.04) than heterosexual women with exclusively male partners. Gay men and gay men reporting same-sex behavior were twice as likely to report food insecurity and severe food insecurity, no matter how sexual orientation was defined.

Conclusion

Food insecurity is a substantial concern for SMW and SMM. Alarmingly, among SMW, food insecurity may contribute to current and increased daily smoking. Future research must consider how food insecurity gives rise to smoking to develop tailored cessation interventions that engage food insecure SMW in successful quitting. This study indicates that food insecurity disparities are evident for all subgroups of SMW and gay men. Community-based solutions to increase food access and policies that alleviate poverty are needed to decrease the considerable food insecurity disparities evidenced across sexual minority populations.

Introduction

Cigarette smoking is a significant concern for sexual minority women (SMW; women who identify as lesbian or bisexual, experience same-sex attraction, or engage in same-sex sexual behavior) and men (SMM; men who identify as gay or bisexual, experience same-sex attraction, or engage in same-sex sexual behavior). According to the 2018 National Health Interview Survey (NHIS), approximately 1 in 5 SMW and 1 in 4 SMM report current cigarette smoking.[1,2] This prevalence is much higher than rates documented among heterosexual people. Multiple, high quality, population-based studies indicate that subgroups of SMW and SMM evidence substantially higher prevalence of cigarette smoking than heterosexuals: For example, lesbian women are 1.5-2.5 times[3-10] more likely to currently smoke than heterosexual women and bisexual women are 1.6-3.5 times more likely.[2-10] Gay men are 1.5-2.4 times more likely to current smoke than heterosexual men[2,4-6,8] and bisexual men are 1.9-2.4 times more likely.[4,6,8]

SMW and SMM also evidence disparities in smoking intensity. Compared to heterosexual women, lesbians are more likely to report moderate (< 20 cigarettes/day: aOR = 2.14; 95% CI, 1.51-3.05) and heavy daily smoking ($\geq$ 20 cigarettes/day: aOR = 2.29; 95% CI, 1.36-3.88).[11] Similarly, bisexual women are more likely to report moderate daily smoking (aOR = 1.60; 95% CI, 1.05-2.44).[11] Among SMM, gay men are more likely to smoke moderately (aOR = 1.98; 95% CI, 1.39-2.81) than heterosexual men; however, bisexual men are twice as likely to report heavy daily smoking (aOR = 2.10; 95% CI, 1.36-3.88).[11]

The extent of disparate smoking in SMW and SMM is especially concerning as tobacco use is the leading cause of preventable chronic disease.[12] Cigarettes also evidence a dose-response relationship with chronic disease. For example, smoking 6-9 cigarettes per day (vs. not smoking) is associated with a 250% increased risk for developing rheumatoid arthritis (RR = 2.5; 95% CI, 1.3-4.7) whereas smoking 10-19 cigarettes per day is associated with a 300% increased risk (RR = 3.0; 95% CI, 2.0-4.6).[13] In asymptomatic adults, smoking more than 10 cigarettes per day (vs. not smoking) is also associated cardiovascular disease (CVD) risk, where more cigarettes smoked (e.g., 10-19, 20-30, >30 vs. not smoking) is associated with 44-252% increased risk of developing CVD.[14] Finally, in women there is evidence that odds of having a stroke increases with number of cigarettes smoked daily (vs. nonsmokers) from 220% among 1-10 cigarettes/per day smokers to 430% for 21-39 cigarettes/per day smokers.[15] Given this evidence, smoking may be driving chronic diseases evidenced in SMW and SMM, including

arthritis,[16] asthma,[17] CVD,[18,19] chronic bronchitis,[16] and hypertension.[16] To decrease tobacco-related chronic disease disparities, studies identifying modifiable determinants of smoking are needed to develop targeted cessation interventions for SMW and SMM.[20,21]

To date, evidence indicates that multiple demographic (age,[22,23]), socioeconomic (education level,[22,23] lack of health insurance[24], limited healthcare access[25,26]), psychosocial factors (frequent bar attendance, [24] alcohol use,[22,23,25,26] illegal drug use,[22,23] depression,[25] poor mental health,[26] childhood physical abuse[23]), and minority stressors (victimization[27], threat of violence[27], discrimination[4]) may explain cigarette smoking in SMW and SMM. However, these variables do not wholly explain smoking disparities in sexual minority adults.[25,26] Accordingly, studies examining factors that may further explain sexual orientation disparities in smoking are needed.

Food Insecurity and Smoking

While smoking has declined steadily in the general U.S. population, food insecure and low-income adults continue to report disproportionately high prevalence of cigarette smoking.[28-33] Food security, defined as "access by all people at all times to enough food for an active, healthy life", is one relatively unexplored factor that may explain smoking disparities evidenced in SMW and SMM.[34] In the U.S., food insecurity is considered an indicator of economic stability,[35] yet the United States Department of Agriculture (USDA) measures of food insecurity ask respondents about past year anxiety regarding food insufficiency, lived experiences of food insufficiency, inability to afford food, coping strategies for managing food insufficiency, and health consequences of food insufficiency.[36] In general, socioeconomic factors are those related to the interaction of social and economic factors (e.g., ability to afford food) while psychosocial factors are those related to the interaction of social factors and individual thoughts, feelings, and behaviors. As such, we consider food insecurity a complex variable at the intersection of socioeconomic and psychosocial factors.

In the general population, food insecurity (i.e., not having enough food for an active healthy life) is independently associated with smoking even when controlling for demographic, economic, psychosocial, and behavioral factors.[28-33] Local, regional, and national cross-sectional studies indicate that food insecure adults are 1.20-2.30 times more likely to report current smoking than individuals who are food secure.[29,30,32,33,37] However, estimates vary by subpopulation and by measurement of food insecurity. For example, in a local study of adults in New York, respondents reporting they did not have enough food to eat at home, were 77% more likely to

currently smoke than those reporting that they rarely or never experienced having insufficient food (aOR = 1.77; 95% CI, 1.35-2.33).[30] Moreover, in a U.S. population-based study, adults who reported that they were “always”, “usually” or “sometime” worried about having enough money to buy nutritious meals were 20% more likely to report being a current smoker (aOR = 1.20; 95% CI, 1.05-1.35) than adults who did not experience these worries.[29] Despite this evidence linking food insecurity and smoking in the general population, no published studies have investigated how food security may be associated with smoking in SMW and SMM. Our study fills this gap by investigating associations between food insecurity and smoking in a population-based sample of SMW and SMM.

There is some debate in the literature as to how food insecurity and smoking are associated. Some researchers argue that food is an “opportunity cost” such that smokers forgo purchasing food to purchase cigarettes.[32,33] This hypothesis is supported by two cross sectional studies where households that included an adult smoker were 44-220% more likely to experience food insecurity.[32,33] However, evidence suggests that the relationship between food security and smoking is more complex than suggested by an opportunity cost hypothesis.[28] In a study of U.S. adults, nonsmokers at baseline who became food insecure (vs. remaining food secure) were over 3 times more likely to start smoking by follow-up (aOR = 3.77; 95% CI = 1.25-11.32).[28] Moreover, smokers at baseline who became food insecure (vs. remaining food secure) were 34% less likely to quit smoking by follow-up (aOR = 0.66; 95% CI, 0.46-0.94).[28] Conversely, smokers who were food insecure at baseline but became food secure (vs. remaining food insecure) were 20% more likely to quit smoking by follow-up (aOR = 1.20; 95% CI = 1.04-1.39).[28] Likewise, in a longitudinal cohort study of homeless and unstably housed women, respondents experiencing food insecurity (vs. being food secure) were 68% more likely to report smoking over time (aOR = 1.68, 95% CI = 1.02-2.78).[31] Given this evidence that food insecurity causally predicts smoking behaviors, we hypothesize the smoking is a strategy used by adults to cope with food insecurity. As such, we hypothesize that current smoking and smoking intensity will be higher in food insecure SMW and SMM than in food secure SMW and SMM.

Food Insecurity in SMW and SMM

Fundamental cause theory and Warnecke’s determinants of health model suggest that structural, sexual orientation-related discrimination experienced by SMW and SMM (i.e., structural minority stress[21]) results in depleted social and economic resources, which contribute to individual-level economic insecurity (i.e., food insecurity), and consequent health disparities

(i.e., smoking to cope with food insecurity). Yet only two published reports have investigated food insecurity in sexual minorities using population-level data.[38,39] The first, released in 2014, used the Gallup Daily Tracking Survey to assess food insecurity in heterosexual, sexual minority, and transgender adults (i.e., individuals whose gender identity does not match the sex they were assigned at birth[40]). Almost 1 in 3 lesbian, gay, bisexual, and transgender (LGBT) adults reported not having enough money for food at some time of the past 12-months (29%), which was significantly different from the proportion of non-LGBT adults who also responded affirmatively (18%, $p < .05$).[39] After adjusting for gender, age, race/ethnicity, and educational attainment, multivariable analyses indicated that LGBT-identified individuals were 67% more likely to report not having enough food over the past year compared to heterosexuals.[39] Finally, significant differences were also indicated by gender. Compared to cisgender (i.e. individuals whose gender identity matched the sex they were assigned at birth[40]) and/or heterosexual women, more LGBT women reported not having enough money to buy food over the past year (20% vs. 34%, $p < .05$).[39] Similarly, compared to cisgender and/or heterosexual men, more LGBT men reported not having enough money to buy food over the past year (16% vs. 25%, $p < .05$).[39] Gender-stratified estimates were not examined in multivariable analyses.[39]

The second report, released in 2016, added the NHIS to Gallup estimates. The NHIS defines food security according to the USDA Household Food Security Survey such that food insecurity is operationalized as having three affirmative responses out of ten questions on past 30-day experiences of food security.[41] This measure provides a more comprehensive measure of food security by inquiring about food access and consumption. Similar to the 2014 report, estimates from the Gallup survey indicated that more LGBT than cisgender and/or heterosexual adults reported not having enough money to pay for food within the past 12-months (27% vs 17%, $p <.05$).[38] Adjusted analyses indicated that, compared to non-LGBT people, LGBT people were 62% more likely to report not having enough money to pay for food (aOR = 1.62, $p < .05$).[38] However, when food security was defined using a more comprehensive measure via the NHIS, results did not indicate significant differences between sexual minority and heterosexual adults in bivariate analyses (12% vs. 11%, p = n.s.) nor multivariable models (aOR = 1.19, p = n.s.).[38]

The lack of significant results found in the NHIS sample may stem from its 30-day recall period. There is some evidence that food security fluctuates across seasons[42] and is pronounced in vulnerable, low-income groups due to employment variability[43] and cost variations (e.g., heating/cooling costs).[44] Consequently, the period during which a survey is distributed across

the year may differentially capture food insecurity among respondents who have previously experienced food insecurity or who regularly experience seasonal food insecurity. As such, studies using comprehensive measures of food security with longer recall periods (e.g., 12 months) are needed to ascertain the breadth of disparities in SMW and SMM. To fill this gap, our study investigates disparities in food insecurity in SMW/SMM compared to heterosexual adults, using a comprehensive measure of food security, the USDA Household Food Security Survey, and 12-month recall period.

Measuring Disparities in SMW and SMM

Most studies investigating sexual minority health disparities define sexual orientation by identity only (i.e. whether someone self-identified as lesbian, gay, or bisexual; LGB).[45] However, best practices for sexual orientation measurement recommend measuring multiple dimensions of sexual orientation—identity, attraction, and behavior—in order to capture hidden subgroups of heterosexual women and men who report same-sex attraction or behavior.[46] Theoretically, subgroups of SMW and SMM defined in terms of multiple dimensions of sexual orientation (e.g., heterosexual women who also report same-sex behavior; heterosexual WSW) confer unique risks for health disparities, including smoking.

Minority stress theory suggests that SMW and SMM experience stressors related specifically to their non-heterosexual sexual orientation that drive risky health behaviors and health outcomes.[21] Theoretically, minority stressors are both proximal (e.g., internalized homophobia) and distal (e.g., experiencing discrimination and victimization). Proximal stressors are subjective and related to a person's self-identification as lesbian, gay, or bisexual. Distal stressors are objective experiences of discrimination and victimization based on a person's actual or perceived minority sexual orientation. Consequently, individuals who identify as LGB are at risk for experiencing both proximal and distal stressors, which may negatively influence health.[21]

However, it can be argued that heterosexual women and men who engage in same sexual behavior (heterosexual WSW and heterosexual MSM) may also experience distal stressors.[21] One example is fearing discrimination from a broader social network who assume that holding a heterosexual identity confers heterosexual sexual behavior. Studies indicate that heterosexual women and men who hide same-sex behavior may fear sexual orientation-related discrimination or victimization.[47-49] While this phenomena was originally examined in black communities of heterosexual MSM, emerging studies document this experience in diverse racial/ethnic

groups[50,51] and rural communities.[52,53] Heterosexual WSW/MSM in such communities may confer risk for poor health arising from distal minority stress. Accordingly, using multiple measure of sexual orientation to define subgroups of sexual minorities may reveal nuances about cigarette smoking disparities in diverse groups of heterosexual WSW/MSM.

Emerging evidence supports this hypothesis.[4,54] In a national study of women aged 20 to 44, heterosexual women with a past-year same sex sexual partner (heterosexual WSW) were more likely to currently smoke than exclusively heterosexual women (46.1 vs 19.4%, $p < .001$).[54] In a second study, heterosexual women attracted to women were 1.5 times more likely to report current smoking than heterosexual women attracted solely to men (aOR = 1.5; 95% CI=1.29-1.76).[4] No differences were evidenced for heterosexual men reporting attraction to men (vs. heterosexual men attracted solely to women). Together, these studies provide support for defining sexual orientation using multiple measures (e.g., identity and sexual behavior) to identify hidden and, potentially vulnerable populations—including heterosexual WSW and heterosexual MSM. However, to our knowledge, no studies have examined smoking behaviors in diverse groups of food insecure SMW and SMM. To fill this gap, this study investigates how food insecurity is associated with smoking behaviors in populations of SMW and SMM defined by multiple measures of sexual orientation (i.e., by sexual identity and in terms of sexual identity and same-sex behavior).

Given the consistent documentation of smoking disparities in SMW and SMM and emerging evidence for food insecurity as a predictor of smoking in the general population, we formed this study with the following aims:

- **Aim 1**: **Determine associations between food security and smoking behaviors in sexual minority women and men.**
  Hypothesis 1: SMW and SMM experiencing food insecurity will evidence greater cigarette smoking than food secure SMW and SMM.
  Hypothesis 2: SMW and SMM experiencing severe food insecurity will evidence greater cigarette smoking than food secure SMW and SMM.
  Question 1. How is food security associated with nicotine dependence and cigarette smoking intensity in SMW and SMM who smoke?

- **Aim 2: Investigate disparities in food insecurity experienced by subgroups of SMW and SMM defined by sexual identity only and in terms of sexual identity and behavior using a comprehensive measure of food security.**
  Hypothesis 3: SMW and SMM will evidence greater food insecurity than heterosexuals.
  Question 2: How do disparities in food insecurity vary by how we define sexual orientation (i.e., by sexual identity only or in terms of sexual identity and behavior)?
  Question 3. How do disparities in food insecurity vary by sexual orientation subgroup (e.g., lesbian vs. bisexual vs. heterosexual women)?

Methods

Study Design

This study used publicly available data from the National Health and Nutrition Examination Survey (NHANES) pooled across ten years, 2005-2014. NHANES is a national probability, repeated cross-sectional survey of U.S. adults and children ≥ 12 years old that assesses health and nutrition status using interviews and medical examinations. NHANES includes data on multiple preventable chronic diseases, risk behaviors (e.g., smoking), psychosocial factors (e.g., mental health), and food security. Detailed information about NHANES study design and sampling frame is described elsewhere.[55,56]

NHANES data may be used for studying disparities in sexual minority subgroups (e.g., lesbian vs. bisexual women) as data can be pooled across multiple years to create larger samples. In this study, women and men completing the 2005 to 2014 sexual behavior surveys (5 cycles across 10 years) were included in analyses. Survey response rates ranged from 71.0-80.5% for the interview component and 68.5-77.4% for the physical exam. From 2005 to 2014, 20,224 respondents completed the sexual behavior survey, which included sexual orientation measures for female and male respondents.

NHANES data vary across survey years such that some data (e.g., alcohol use) are not publicly available for the subsample of respondents < 20 years old at time of interview. Moreover, some sexual orientation questions (e.g., sexual identity) are not asked of respondents ≥ 60 years old at time of interview. Consequently, our study sample is restricted to respondents aged 20 to 59 years old. Additionally, respondents were excluded from analyses if they did not answer the following questions: sexual identity, lifetime same-sex sexual behavior, or 12-month same-sex

sexual behavior; and tobacco use food security, alcohol use, or depressive symptoms. The final analytic sample included 7,772 women and 7,430 men who responded to the NHANES sexual behavior survey and met study inclusion/exclusion criteria.

Prior studies have successfully pooled NHANES sexual identity and behavior data to examine behavioral risk and low prevalence health disparities in sexual minority populations.[16,19,57-61] Using 2001-2012 pooled NHANES data, Caceres et a. (2018) were able to investigate subgroup differences in CVD risk among gay-identified (n = 147), bisexual-identified (n = 114), heterosexual men who have sex with men (MSM) (heterosexual MSM; n = 179) and exclusively heterosexual (n = 7291) men.[57] Similarly, using NHANES data pooled from 2009-2014, Patterson and Jabson (2017) examined chronic disease disparities by sexual identity in women (lesbian, n = 63; bisexual, n = 225; heterosexual, n = 4446) and men (gay, n = 93; bisexual, n = 69; heterosexual, n = 4406). This study also assessed differences across in SMW and SMM defined by sexual identity only, sexual behavior only, and in terms of sexual identity and lifetime sexual behavior, including: heterosexual WSW (n = 228), lesbian or bisexual WSW (n = 232), heterosexual MSM (n = 95), and gay or bisexual MSM (n = 135).[16]

Analytic Framework for Empirical Variable Selection

Based on study aims, our analytic interests are twofold:

- Aim 1: To determine if food insecurity is independently associated with smoking.
- Aim 2: To determine if sexual orientation is independently associated with food insecurity.

A consistent challenge of sexual minority health research is managing small samples.[62,63] Under optimal population-based sampling strategies, approximately 3%–5% of respondents identify as sexual minorities.[45] These sample sizes substantially limit our ability to power analyses while controlling for sources of confounding. For example, when investigating the independent association between food insecurity and smoking there may be covariates (i.e., age, poverty, health insurance status) that may also influence smoking. To estimate the independent association between food security and smoking, we must address any confounding these covariates introduce into statistical models.

A traditional approach for addressing confounding is to adjust for covariates through stratification or inclusion in a regression model. However, modern epidemiological methods

suggest that regression models which include unnecessary covariates may introduce bias into analyses.[64] Moreover, by including too many covariates in a model that is limited by sample size, we substantially reduce our power and risk Type II error.[65] One solution that protects power in the context of small samples is to use directed acyclic graphs (DAGs) to empirically inform covariate selection for regression models.[66,67]

As introduced by Pearl (1999), DAGs graphically depict the most plausible causal relationships between exposure, outcome, and measured or unmeasured covariates (Figure 4.1).[67] More specifically, via DAGs, researchers transparently present a priori assumptions about assumed directional relationships between exposure, outcome, and covariates as surmised from extant theory and substantive knowledge.[67,68] While causation cannot be definitively proven in observational studies limited by cross-sectional data, DAGs can guide researchers in identifying sources of confounding of plausible causal relationships and, thus, determining the minimally sufficient sets of covariates to include or exclude in regression models to reduce bias.

This first step in creating DAGs is to graphically depict all plausible causal associations (called paths) between variables (called nodes). Paths are depicted with arrows (called “edges”), and hypothesized directional paths are denoted by the direction of the arrows leading from ancestor to descendent nodes. A directed path is any unbroken route that can be traced from one node to another through a sequence of edges. Because causality requires temporality, causal DAGs are linear and acyclic: A variable cannot cause itself, either directly or through other variables unless time is also accounted for. For example, smoking *at time 1* (t1) could be hypothesized to decreased available funds, leading to psychological distress, contributing to smoking *at time 2* (t2). In a DAG depicting this association, two nodes would need to be included to represent smoking (at t1 and t2).

The second step is to identify “backdoor paths” that exist between variables of interest. Backdoor paths connect exposure and outcome variables through a series of covariates; however, *backdoor paths are not reliant on the direction of edges connecting nodes.* To identify backdoor paths that confound the association between exposure and outcome, we must identify “collider” and “noncollider” nodes. Colliders are nodes influenced by more than one variable in the DAG. In DAGs, the edges directed into this node “collide” such that both arrows point into the collider node (see Figure 4.1, node “C’ in examples 2 and 3). “Noncolliders” represent all other covariates that are not colliders (see Figure 4.1, nodes “A” and “M” in examples 4 and 5).

Confounding backdoor paths are dependent on how we condition for collider and noncollider variables in regression analyses. First, we may create a confounding path by conditioning on a collider in regression analyses (see Figure 4.1, example 2). In this example, common effects (colliders) imply association such that conditioning on colliders creates a backdoor path between the two parent nodes that share the collider as a common effect. To block this confounding backdoor path, we do not condition on the collider. Similarly, if we condition on a descendent node of a collider, then we also create a backdoor path between the two nodes that share the collider as a common effect (see Figure 4.1, example 3). To block this backdoor path, we do not condition on the descendent of the collider. Second, confounding backdoor paths are created when nodes share a common ancestor (see Figure 4.1, example 4). To block this confounding path, the common ancestor (a noncollider) *must* be conditioned on in regression analyses. Identifying these types of confounding backdoor paths allows researchers to determine whether conditioning on a specific covariate in a regression model will block (or introduce) confounding into direct effects estimates.[69,70]

In addition to identifying confounding paths, we must also identify paths that contain mediating variables (i.e., covariates hypothesized to explain some (or all) of the association between exposure and outcome; see Figure 4.1, example 5). Mediators must be conditioned on in order to estimate the direct association between exposure and outcome.

Once all of the confounding backdoor paths and mediating paths between exposure and outcome are identified, we must determine which set of nodes are sufficient to block all pathways between exposure and outcome, except the association of interest (exposure → outcome). Nodes are considered "d-separated" (fully blocked) if all pathways that contain: (1) colliders that have not been conditioned on (including descendants of colliders) and (2) noncolliders that have been conditioned on. If all paths except the pathway of interest are d-separated, the net association between exposure and outcome may be interpreted as conditionally independent.[67,69]

Pearl's (1993) backdoor path criterion aids researchers in identifying which variables they must (and must not) condition on to effectively block backdoor paths between exposure and outcome variables. The backdoor path criterion indicates that a set of variables (S) is *sufficient* to control for confounding if: (1) S blocks every backdoor path between exposure and outcome and (2) S does not include any descendants of the exposure. Once the backdoor path criterion is met,

then we can estimate (through conditioning on S) the direct effect between exposure and outcome).[67,71]

While backdoor paths are relatively simple to identify in DAGs containing a handful of variables, for more complex DAGs computer programs are available for creating graphic models and estimating minimal sufficient adjustment sets (MSAs; described by Pearl as the variable set, "S"[71]).[72] DAGitty (www.daggitty.net) is one such open-source program. In addition to mapping graphical diagrams, DAGitty produces MSAs and outlines assumptions that explain relationships between variables.[72]

To identify MSAs necessary for estimating the direct association between exposure and outcome for each study aim, we constructed two working DAG models (see Figures 2 and 3). To develop DAGs, we applied Waerneke's Fundamental Cause Theory and empirical evidence to identify covariates of sexual orientation, food security, and/or smoking. Importantly, using DAGitty v3.0 to organize graphical models, identify backdoor pathways and associated confounding,[72] we were able to identify a set of covariates minimally sufficient for predicting the independent association between exposure and outcome for each study aim.

Identifying Aim 1 MSAs

Figure 4.2 displays the DAG of food insecurity and cigarette smoking (Aim 1). In this working model, we present the most plausible causal paths between food insecurity and smoking so as to identify confounders and determine MSAs to include in regression models. In this model, we assume that multiple factors may give rise to food insecurity and cigarette smoking via identity-related discrimination and subsequent depletion of social and economic resources which, in turn, influences individual economic, psychosocial, and behavioral factors. Blue ovals indicate antecedents of smoking (i.e., risky drinking). Red ovals indicate antecedents of food security *and* cigarette smoking and, thus, confounders of the association between food security and smoking. White ovals represent unmeasured variables. Gray ovals represent variables that are known sexual orientation-related health disparities but do not confound associations between food security and smoking (e.g., depressive symptoms). Food insecurity is assumed to be associated with cigarette smoking. Using DAGitty, we were able to identify confounding backdoor pathways and conditions under which we could d-separate these pathways.

- Food insecurity ⊥ Sexual orientation | Health insurance status, Poverty
  Food insecurity is independent of sexual orientation controlling for health insurance and poverty.
- Food insecurity ⊥ Race/Ethnicity | Health insurance status, Poverty
  Food insecurity is independent of race/ethnicity controlling for health insurance and poverty.
- Food insecurity ⊥ Age | Health insurance status, Poverty
  Food insecurity is independent of age controlling for health insurance and poverty.
- Food insecurity ⊥ Gender | Health insurance status, Poverty
  Food insecurity is independent of gender controlling for health insurance and poverty.
- Food insecurity ⊥ Risky drinking | Health insurance status, Poverty
  Food insecurity is independent of risky drinking controlling for health insurance and poverty.
- Educational attainment ⊥ Food insecurity | Health insurance status, Poverty
  Educational attainment is independent of food insecurity controlling for health insurance and poverty.

Considering the assumptions above and following Pearl's backdoor path criterion, we identified poverty and health insurance as covariates comprising an MSA that d-separated all pathways except between food insecurity and smoking.

Identifying Aim 2 MSAs

Figure 4.3 displays the DAG of sexual orientation and food insecurity (Aim 2). In this working model, we present the most plausible causal paths between sexual orientation and food insecurity so as to identify confounders and determine MSAs for regression models. In this model, we assume that SMW and SMM experience sexual orientation-related discrimination, an unmeasured variable but fundamental cause of disparities. Experiencing sexual-orientation related discrimination leads to depletion of social and economic resources, which influence individual economic, psychosocial, and behavioral factors. Of these, poverty and health insurance are hypothesized to lead to food insecurity. Blue ovals indicate antecedents of food insecurity (e.g., poverty). White ovals represent unmeasured variables. Gray ovals represent variables that are known sexual orientation-related health disparities but do not confound associations between sexual orientation and food insecurity (e.g., depressive symptoms). Using

DAGitty, we were able to identify confounding backdoor pathways and conditions under which we could d-separate these pathways.

- Food insecurity ⊥ Age | Health insurance status, Poverty, Sexual orientation
  Food insecurity is independent of age, controlling for health insurance, poverty, and sexual orientation
- Food insecurity ⊥ Race/Ethnicity | Health insurance status, Poverty, Sexual orientation
  Food insecurity is independent of race/ethnicity, controlling for health insurance, poverty, and sexual orientation
- Food insecurity ⊥ Gender | Health insurance status, Poverty, Sexual orientation
  Food insecurity is independent of gender, controlling for health insurance, poverty, and sexual orientation
- Food insecurity ⊥ Risky drinking | Health insurance status, Poverty, Sexual orientation
  Food insecurity is independent of risky drinking, controlling for health insurance, poverty, and sexual orientation
- Educational attainment ⊥ Food insecurity | Health insurance status, Poverty, Sexual orientation
  Educational attainment is independent of food insecurity, controlling for health insurance, poverty, and sexual orientation

Considering the assumptions above and following Pearl's backdoor path criterion, we identified poverty and health insurance as covariates that comprised a MSA that d-separated all pathways except between sexual orientation and food insecurity.

Measures

Sexual Orientation. NHANES measured sexual orientation with one question about sexual identity and two questions about sexual behavior. For this study, sexual orientation was defined by (1) sexual identity-only, and in terms of (2) sexual identity and lifetime sexual behavior, and (3) sexual identity and 12-month sexual behavior (Table 4.1).

Sexual identity questions were asked of NHANES' female and male respondents aged 18–59 years. Women were asked, "Do you think of yourself as heterosexual or straight (i.e., sexually attracted only to men); homosexual or gay (i.e., sexually attracted only to women); bisexual (i.e., sexually attracted to men and women); something else?" Men were asked, "Do you think of yourself as heterosexual or straight (i.e., sexually attracted only to women); homosexual or gay

(i.e., sexually attracted only to men); bisexual (i.e., sexually attracted to women and men); something else?"

For Aim 1, where SMW were defined by sexual identity only, subgroups of sexual minority women were coded as lesbian (coded 0) or bisexual (coded 1) and men were coded as gay (coded 0) or bisexual (coded 1). For Aim 2, where women were defined by sexual identity only, subgroups were coded as bisexual (coded 2), lesbian (coded 1), or heterosexual (coded 0) and men were coded as bisexual (2), gay (1), or heterosexual (coded 0).

Sexual orientation was also defined in terms of sexual identity and sexual behavior and coded according to previous publications.[16] NHANES' respondents were asked to report the number of same- and opposite-sex partners with whom they had engaged in sexual behavior over the life course and during the past 12-months.

To address Aim 1, we defined SMW and SMM in terms of sexual identity and sexual behavior as follows: Women identifying as lesbian and reporting any same-sex behavior were defined as lesbian WSW (coded 1); men identifying as gay and reporting any same-sex behavior were defined as gay MSM (coded 1). Women or men identifying as bisexual and reporting any same-sex behavior were defined as bisexual WSW (coded 2) or bisexual MSM (coded 2). Women or men identifying as heterosexual and reporting any same-sex behavior were defined as heterosexual WSW (coded 0) or heterosexual MSM (coded 0).

To address Aim 2, we defined women and men in terms of sexual identity and sexual behavior as follows: Women or men reporting heterosexual identity and exclusively opposite sex behavior were defined as heterosexual women who have sex with men (heterosexual WSM; coded 0) or heterosexual men who have sex with women (heterosexual MSW; coded 0). Women identifying as lesbian and reporting any same-sex behavior were defined as lesbian WSW (coded 1); men identifying as gay and reporting any same-sex behavior were defined as gay MSM (coded 1). Women or men identifying as bisexual and reporting any same-sex behavior were defined as bisexual WSW (coded 2) or bisexual MSM (coded 2). Women or men identifying as heterosexual and reporting any same-sex behavior were defined as heterosexual WSW (coded 3) or heterosexual MSM (coded 3).

Food Security. NHANES' food security measure is based on the USDA Food Security Survey (α = 0.74-0.93[73]). The survey module asks individuals and families to report their experiences with food security across 4 domains, including: (1) anxiety about food supplies, (2) perceptions that quality or quantity of food is not adequate, and reduced food intake by (3) adults or (4) children (if applicable). Food security is assessed over the past 12 months using a scale of 0-10 for households without children and 0-18 for households with children. Levels of household (HH) food security are designed as "full food security" (0 points), "marginal food security" (1-2 points), "low food security" (3-5 points HH without child, 3-7 points HH with child), and "very low food security" (6-10 points HH without child, 8-18 points HH with child). The original NHANES item were recoded so that households were considered food secure if scores ≤ 2 (i.e., full or marginal food security; coded 0) and food insecure if scores ≥ 3 items (low or very low food security; coded 1).[36] For sensitivity analyses, the original NHANES item was recoded so that households were considered food secure if scores ≤ 5 (HH without child) or ≤ 7 (HH with child) (i.e., full marginal, or low food security; coded 0) and severely food insecure if scores ≥ 6 (HH without child) ≥ 8 (HH with child) (very low food security; coded 1).

Current Smoking. Current smoking is the most frequently assessed measure of tobacco use in the scientific literature, and is defined by measurement criteria set forth by the Centers for Disease Control. Current cigarette smoking is assessed by having smoked ≥ 100 cigarettes ever and currently reporting smoking on either "some" or "every" day.[1] NHANES assessed current cigarette smoking with the question "Have you smoked at least 100 cigarettes in your entire life?" and the conditional follow-up question, "Do you now smoke cigarettes?" We defined respondents who reported not smoking 100 cigarettes in their lifetime or having smoked at least 100 cigarettes in their lifetime but currently not smoking as non-smokers (coded 0). Those who reported smoking at least 100 cigarettes in their lifetime and currently smoking cigarettes either "every day" or "some days" were defined as current smokers (coded 1).[12]

Cigarette Smoking Intensity. NHANES assessed number of current cigarettes smoked per day among current smokers with the question, "During the past 5 days, including today, on the days you smoked, how many cigarettes did you smoke each day?" Responses were recorded on a continuous scale from 1-95.

Time to First Cigarette. Time to first cigarette (TTFC), an item of the Fagerstrom Test for Nicotine Dependence,[74] is an objective measure of nicotine dependence[74] and is associated

with ability to quit smoking.[75,76] NHANES measures TTFC among current smokers with a single question, “How soon after you wake up do you smoke? Would you say….” Responses include, “within 5 minutes”, “from 6 to 30 minutes”, “30 minutes to one hour”, “1 hour to 2 hours, “2 hours to 3 hours”, “3 hours to 4 hours”, and “more than 4 hours.” Responses were dichotomized such that respondents were defined as nicotine dependent if they reported smoking the first cigarette within 30 minutes of waking (coded 1) or not dependent on nicotine if they reported smoking more than 30 minutes after waking (coded 0).

Covariates

Family Poverty to Income Ratio (PIR). PIR was calculated by dividing family income by the Health and Human Services Poverty guidelines specific to family size, year and state.[77] For descriptive analyses, PIR was presented by U.S. Census defined poverty thresholds (<100%, 100-199%, 200-299%, 300-399%, ≥400%).[78] Individuals with income < 100% of the poverty threshold (hereafter referred to as “federal poverty line”; FPL) are considered in poverty (“poor”) and those with incomes 100-199% FPL are considered near poverty (“near poor”).[79] For regression analyses PIR was dichotomized to create poverty categories that combined poor (<100% FPL) and near poor (100-199% FPL) respondents versus those with higher incomes (≥ 200% FPL) economic status groups.

Health Insurance Status. NHANES assessed health insurance coverage with the question, “Are you covered by health insurance or some other kind of health care plan?” and the conditional follow-up question “What kind of health insurance or health care coverage you have?” For summary statistics, responses were recoded to capture respondents covered by private insurance, Medicare/Medigap, Medicaid, other public insurance, or who were uninsured. In multivariable analyses, insurance categories were collapsed to define health insurance coverage as private (coded 0), public (coded 1), or none/uninsured (coded 2).

Demographic, Socioeconomic, Psychosocial, and Behavioral Variables

Summary statistics were calculated to describe demographic, socioeconomic, psychosocial, and behavioral characteristics. Age was recoded into four categories representing respondents across emerging (18-25), young (26-35), middle (36-45), mid-late (46-59) stages of adulthood. NHANES’ original variable structure was retained for marital status (married, widowed, divorced, separated, never married, and living with partner) and race/ethnicity categories (non-Hispanic white, non-Hispanic black, Mexican American, other Hispanic, and other race including

multiracial). Education level was recoded into three categories (≤ high school/GED, some college/Associate's degree, college graduate or higher).

Depressive Symptoms. NHANES assessed depressive symptoms with the Patient Health Questionnaire-9 (PHQ-9).[80] Participants were asked, "Over the last 2 weeks, how often have you been bothered by any of the following problems?" for each of the 9 DSM-IV criteria, which included such items as "little interest or pleasure in doing things" and "feeling down, depressed, or hopeless".[80] Depression severity was calculated by assigning scores of 0, 1, 2, and 3, to the response categories of "not at all," "several days," "more than half the days" and "nearly every day." PHQ-9 total score ranges from 0 to 27 where a higher score indicates greater depressive symptoms.[80] For summary statistics,[80] PHQ-9 scores were recoded [80] to describe minimal (0-4), mild (5-9), moderate (10-14), moderately severe (15-19), and severe (20-27) levels of depressive symptoms.

At-risk Alcohol Use. At-risk drinking was assessed in NHANES with a series of questions about lifetime, 12-month, and average daily/weekly/monthly use. Women were defined as at-risk drinkers (coded 1) if, during the past 12 months, they reported having > 7 or more drinks per week.[81] Men were defined as at-risk drinkers (coded 1) if, during the past 12 months, they reported having > 14 drinks per week.[81]

Analyses

We weighted analyses for complex survey design as specified by NHANES' Analytic and Reporting Guidelines.[82] Analyses were stratified by gender as recommended by the Institute of Medicine[62] and using the subpop command in Stata to account for the complex survey design.

Aim 1: Analyses

First, summary statistics described SMW and SMM across demographic, socioeconomic, psychosocial, and behavioral variables. We assessed differences between sexual minority subgroups with Likelihood ratio X2 (LR X2) test for proportions. Then unadjusted, weighted bivariate analyses examined associations between food insecurity and smoking behaviors (i.e., current smoking, nicotine dependence, smoking intensity) in SMW and SMM defined by sexual identity, in terms of sexual identity and lifetime sexual behavior, and in terms of sexual identity and 12-month sexual behavior. For current smoking and nicotine dependence, we reported

weighted point estimates as percentages with standard errors, associated test statistics, and p-values. Because smoking intensity was defined as average number of cigarettes per day (range: 1-95), regression models that could account for count data for which the value of zero cannot occur were warranted. Consequently, we used unadjusted zero-truncated negative binomial regression to estimate bivariate associations. Overdispersion was assessed via the log of the overdispersion paramater alpha wherein an (ln)alpha of zero indicates that a zero-truncated Poisson model is a better fit.[83] We reported exponentiated regression coefficients as incidence-rate ratios (IRRs) with associated 95% confidence intervals (95% CIs).

Third, simultaneous, weighted, multivariable logistic regression models estimated direct effects between food insecurity and current smoking in SMW and SMM. We reported exponentiated logistic regression coefficients as adjusted odds ratios (aORs) with associated 95% CIs.

Simultaneous, weighted, multivariable logistic regression models estimated direct effects between food insecurity and nicotine dependence in SMW and SMM smokers. We reported exponentiated logistic regression coefficients as aORs with associated 95% CIs.

Finally, among SMW and SMM smokers, weighted multivariable zero-truncated negative binomial regression estimated associations between food insecurity and smoking intensity. Exponentiated regression coefficients were reported as IRRs with associated 95% CIs. For significant models, postestimation of marginal effects at representative values were calculated to examine the expected numbers of cigarettes smoked daily between food secure and food insecure SMW and SMM smokers, by sexual orientation and poverty level.[84] Graphic displays of margin results were produced using Microsoft Excel. All multivariable analyses were adjusted for DAG-identified covariates and sexual orientation.

Bivariate and multivariable analyses were repeated in sensitivity analyses to assess associations between severe food insecurity and smoking behaviors.

Aim 2: Analyses

First, summary statistics described the sample across demographic, socioeconomic, psychosocial, and behavioral variables. We assessed differences between sexual minority and heterosexual respondents with LR X2 test for proportions.

Second, weighted bivariate analyses examined differences in food insecurity prevalence across diverse sexual orientation subgroups. We used LR X2 test for proportions to assess statistical significance and reported weighted point estimates as percentages with standard errors associated test statistics and p-values.

Third, simultaneous, weighted, multivariable logistic regression models estimated associations between sexual orientation and food insecurity in women and men defined by sexual identity, in terms of sexual identity and lifetime sexual behavior, and in terms of sexual identity and 12-month sexual behavior. Multivariable analyses were adjusted for DAG-identified covariates and sexual orientation. We reported exponentiated logistic regression coefficients as aORs with associated 95% CIs.

Bivariate and multivariable analyses were repeated in sensitivity analyses to assess associations between sexual orientation and severe food insecurity.

We used STATA 14.2 (StataCorp LP, College Station, TX) for all analyses.

Results

Aim 1: Sample Characteristics

Few differences were evidenced in demographic, socioeconomic, psychosocial, or behavioral characteristics between sexual minority subgroups (Table 4.2). Regardless of how sexual orientation was defined, bisexual women and bisexual WSW were younger, less likely to have attained a college degree, more likely to experience higher poverty, and less likely to report minimal depressive symptoms. In contrast, lesbians and lesbian WSW were more likely to have attained a college degree and have private health insurance. When SMW were defined in terms of sexual identity and lifetime sexual behavior, heterosexual WSW were less likely to currently smoke. Across all groups, no differences were seen in at-risk drinking or food insecurity in subgroups of SMW.

Among subgroups of SMM, no differences were evidenced for race/ethnicity or age. However, bisexual men and bisexual MSM were more likely to have attained a high school degree or less and receive Medicaid. Gay men and gay MSM were more likely to report private health insurance and were the least likely to experience poverty. When SMM were defined in terms of

sexual identity and 12-month sexual behavior, heterosexual MSM were more likely to experience poverty than gay MSM. Across all groups of SMM, no differences were evidenced for at-risk drinking, current smoking, or food security.

Aim 1: Associations Between Food Insecurity and Smoking Behaviors

Current Smoking in Women. Weighted bivariate analyses indicated significant associations between food insecurity and current smoking for SMW, no matter how sexual orientation was defined (Table 4.3). Adjusted analyses (Table 4.4) indicated that when SMW were defined in terms of sexual identity and lifetime sexual behavior, food insecurity was associated with current smoking. In this group, food insecure SMW were 70% more likely to report current smoking (aOR = 1.70; 95% CI, 1.11-2.59) than SMW who were food secure. No differences were observed between sexual orientation subgroups in current smoking. However, being poor or near poor (< 200% FPL vs. ≥ 200% FPL) was associated with increased likelihood of current smoking in SMW defined by sexual identity (aOR = 2.01; 95% CI, 1.13-3.58) and in terms of sexual identity and lifetime sexual behavior (aOR = 1.81; 95% CI, 1.12-2.92). In SMW defined by sexual identity, having no health insurance (vs. private health insurance) was also associated with increased likelihood of current smoking (aOR = 2.17; 95% CI, 1.20-3.91).

Weighted, bivariate sensitivity analyses indicated significant associations between severe food insecurity and current smoking only for SMW defined by sexual identity and in terms of sexual identity and sexual behavior (Table 4.5). No matter how sexual orientation was defined, adjusted analyses (Table 4.6) did not evidence significant associations between severe food insecurity and current smoking in SMW. No differences were observed between sexual orientation subgroups in current smoking. However, being poor or near poor (< 200% FPL vs. ≥ 200% FPL) was associated with increased likelihood of current smoking in SMW defined by sexual identity (aOR = 2.06; 95% CI, 1.17-3.61) and in terms of sexual identity and lifetime sexual behavior (aOR = 1.97; 95% CI, 1.20-3.24). In SMW defined by sexual identity, having no health insurance (vs. private insurance) was associated with current smoking (aOR = 2.19; 95% CI, 1.21-3.97).

Current Smoking in Men. In bivariate analyses, significant associations between food insecurity and current smoking were evidenced in SMM defined by sexual identity and in terms of sexual identity and lifetime same-sex behavior (Table 4.3). However, adjusted logistic regression models did not indicate any association between food insecurity and current smoking for SMM,

no matter how sexual orientation was defined (Table 4.4). No differences were observed between sexual orientation subgroups in current smoking. Health insurance was associated with current smoking in SMM defined in terms of sexual identity and sexual behavior (both lifetime and 12-month). Compared to lifetime MSM with private health insurance, lifetime MSM with publicly-funded health insurance or no health insurance were over twice as likely to report current smoking (public: aOR = 2.15; 95% CI, 1.04-4.04; none: aOR = 2.49; 95% CI, 1.28-4.85). Moreover, compared to 12-month MSM with private health insurance, 12-month MSM with no health insurance were over four times as likely to report current smoking (aOR = 4.04; 95% CI, 1.58-10.37).

Weighted bivariate sensitivity analyses indicated significant associations between severe food insecurity and current smoking for SMM no matter how sexual orientation was defined (Table 4.5). In multivariable analyses (Table 4.6), severe food insecurity (vs. being food secure) was associated with over twice the odds of current smoking (aOR = 2.72; 95% CI, 1.01-7.29) when SMM were defined in terms of sexual identity and lifetime sexual behavior. In this group, being poor or near poor (< 200% FPL vs. ≥ 200% FPL) was associated with over twice the odds of reporting current smoking (aOR = 2.11; 95% CI, 1.11-4.01). Moreover, compared to SMM with private health insurance, SMM with public or private health insurance were over twice as likely to report current smoking (public: 2.14; 95% CI, 1.06-4.33; none: 2.45; 95% CI, 1.26-4.75). Finally, in SMM defined in terms of sexual identity and 12-month sexual behavior, SMM with public or no health insurance were over thrice as likely to report current smoking than 12-month SMM with private health insurance (public: aOR = 3.40; 95% CI, 1.01-11.43; none: aOR = 3.50; 95% CI, 1.34-9.15). No differences were observed between sexual orientation subgroups and current smoking.

Nicotine Dependence in Women. Weighted bivariate analyses indicated significant associations between food insecurity and nicotine dependence for SMW defined by sexual identity and in terms of sexual identity and lifetime sexual behavior (Table 4.3). However, adjusted logistic regression analyses did not evidence any association between food insecurity and nicotine dependence for SMW, no matter how sexual orientation was measured (Table 4.4). Moreover, no differences were observed between sexual orientation subgroups and nicotine dependence. However, when sexual orientation was defined by sexual identity and lifetime sexual behavior, SMW who were poor/near poor (< 200% FPL vs. ≥ 200% FPL) were twice as likely to be nicotine dependent (aOR = 2.09; 95% CI, 1.02-4.26).

Neither weighted bivariate sensitivity analyses (Table 4.5) nor adjusted regression analyses (Table 4.6) indicated significant associations between severe food insecurity and nicotine dependence, nor any covariates and nicotine dependence.

Nicotine Dependence in Men. Weighted bivariate analyses indicated significant associations between food insecurity and nicotine dependence for SMM defined by sexual identity (Table 4.3). Adjusted logistic regression analyses also did not evidence any association between food insecurity and nicotine dependence for SMM, no matter how sexual orientation was defined (Table 4.4). Moreover, no differences were observed between sexual orientation subgroups and nicotine dependence. However, in SMM defined in terms of sexual identity and lifetime sexual behavior, being poor or near poor (< 200% FPL vs. ≥ 200% FPL) was associated with over four times the odds of being nicotine dependent (aOR = 4.18; 95% CI, 1.23-14.20).

Weighted bivariate sensitivity analyses (Table 4.5) did not evidence any associations between severe food insecurity and nicotine dependence in SMM, no matter how sexual orientation was defined. Adjusted regression analyses (Table 4.6) did not evidence significant associations between severe food insecurity and nicotine dependence for any SMM. However, when sexual orientation was defined in terms of sexual identity and lifetime sexual behavior, SMM who were poor or near poor (< 200% FPL vs. ≥ 200% FPL) were over four times as likely to be nicotine dependent (aOR = 4.49; 95% CI, 1.21-16.62).

Smoking Intensity in Women. Unadjusted zero-truncated negative binomial regression analyses indicated associations between food insecurity and average number of cigarettes smoked daily for SMW defined by sexual identity and 12-month sexual behavior (Table 4.3). However, adjusted multivariable zero-truncated negative binomial regression analyses (Table 4.4) indicated significant associations between food insecurity and smoking intensity for SMW smokers defined in terms of sexual identity and sexual behavior (lifetime and 12-month). Lifetime SMW who were food insecure reported smoking 33% more cigarettes daily than lifetime SMW who were food secure (IRR = 1.33; 95% CI, 1.07-1.66). When sexual orientation was defined in terms of sexual identity and 12-month sexual behavior, food insecure SMW reported smoking 82% more cigarettes daily than food secure SMW (IRR = 1.82; 95% CI, 1.20-2.74).

In sensitivity analyses, unadjusted zero-truncated negative binomial regression analyses indicated associations between severe food insecurity and average number of cigarettes

smoked daily for SMW smokers defined in terms of sexual identity and 12-month sexual behavior (Table 4.5). Adjusted multivariable zero-truncated negative binomial regression analyses (Table 4.6) indicated significant associations between severe food insecurity and smoking intensity for SMW smokers defined in terms of sexual identity and sexual behavior (lifetime and 12-month). When sexual orientation was defined in terms of sexual identity and lifetime sexual behavior, severely food insecure SMW reported smoking 29% more cigarettes daily than lifetime WSW who were food secure (IRR = 1.29; 95% CI, 1.01-1.66). SMW smokers defined in terms of sexual identity and 12-month sexual behavior reported smoking 62% more cigarettes daily if they were severely food insecure (vs. food secure; IRR = 1.62; 95% CI, 1.05-2.51).

Table 4.7 presents the predicted number of daily cigarettes for SMW defined by sexual identity and sexual behavior (lifetime and 12-month) across all of combinations food security, sexual orientation, and poverty. When sexual orientation was defined by sexual identity and lifetime sexual behavior (Figure 4.4), food insecure lesbian WSW were predicted to smoke the most cigarettes daily, regardless of poverty status: 4.10-4.27 cigarettes per day more than food insecure bisexual WSW and 1.89-1.97 cigarettes per day more than food insecure heterosexual WSW with comparable incomes. However, when sexual orientation was defined by sexual identity and 12-month sexual behavior (Figures 4.5), food insecure heterosexual WSW were predicted to smoke the most cigarettes daily, regardless of poverty status: 3.15-3.82 cigarettes per day more than food insecure lesbian WSW and 5.42-6.58 cigarettes per day more than food insecure bisexual WSW with comparable incomes. Regardless of how sexual orientation was measured, bisexual WSW who were poor/near poor but food secure smoked the least number of cigarettes daily.

Similar results were evidenced in sensitivity analyses ((Figures 4.6 and 4.7). When sexual orientation was defined by sexual identity and lifetime sexual behavior (Figure 4.6), severely food insecure lesbian WSW were predicted to smoke the most cigarettes daily, regardless of poverty status: 4.72-4.81 cigarettes per day more than severely food insecure bisexual WSW and 2.52-2.53 cigarettes per day more than severely food insecure heterosexual WSW with comparable incomes. However, when sexual orientation was defined by sexual identity and 12-month sexual behavior (Figures 4.7), severely food insecure heterosexual WSW were predicted to smoke the most cigarettes daily, regardless of poverty status: 2.38-2.43 cigarettes per day more than food insecure lesbian WSW and 6.96-7.10 cigarettes per day more than food

insecure bisexual WSW with comparable incomes. Regardless of how sexual orientation was measured, bisexual WSW who were food secure and with incomes ≥ 200% FPL smoked the least number of cigarettes daily.

Smoking Intensity in Men. Weighted bivariate analyses indicated significant associations between food insecurity and smoking intensity in SMM defined by sexual identity (Table 4.3). However, adjusted regression analyses did not evidence any significant associations between severe food insecurity and smoking intensity (Table 4.4). When sexual orientation was defined by sexual identity and 12-month sexual behavior, gay MSM reported smoking 62% less cigarettes daily than heterosexual MSM (aOR = 0.38; 95% CI, 0.18-0.81).

Neither weighted bivariate sensitivity analyses (Table 4.9) nor multivariable zero-truncated negative binomial regression analyses indicated significant associations between severe food insecurity and smoking intensity in SMM (Table 4.10). In adjusted analyses, when sexual orientation was defined by sexual identity and sexual behavior (lifetime or 12-month), gay MSM reported smoking 33-60% less cigarettes daily than heterosexual MSM (lifetime: aOR = 0.67; 95% CI, 0.45-0.99; 12-month: aOR = 0.40; 95% CI, 0.19-0.85). When sexual orientation was defined by sexual identity, MSM with publicly-funded health insurance reported smoking 49% more cigarettes per day than MSM with private health insurance (aOR = 1.49; 95% CI, 1.04-2.11).

Aim 2: Sample Characteristics

Table 4.8 summarizes sample demographic, socioeconomic, psychosocial, and behavioral characteristics. All variables are presented for SMW and SMM defined by sexual identity, in terms of sexual identity and lifetime sexual behavior, and in terms of sexual identity and 12-month sexual behavior. Sample sizes differed by how sexual orientation was defined. The greatest proportion of SMW and SMM were evidenced when sexual orientation was defined in terms of sexual identity and lifetime sexual behavior. Of female respondents, 1.2% were lesbian WSW, 3.5% bisexual WSW, and 5.0% heterosexual WSW. Of male respondents, 2.3% were gay MSM, 1.1% bisexual MSM, and 2.2% heterosexual MSM.

There were substantial differences in demographic, socioeconomic, psychosocial, and behavioral characteristics between heterosexual and sexual minority respondents (Table 4.8). Despite how sexual orientation was defined, most SMW in this sample identified as non-

Hispanic White or non-Hispanic Black. Moreover, SMW were significantly younger than heterosexual women. Self-identified bisexual women and bisexual WSW were less likely to have graduated college than their heterosexual counterparts. They were also more likely to report higher poverty, at-risk drinking, and current smoking. Lesbians and lesbian WSW were more likely to report having no health insurance than their heterosexual and bisexual counterparts.

No matter how sexual orientation was defined, no significant differences were evidenced between SMM and heterosexual subgroups for race/ethnicity, age, or current smoking. Self-identified gay men and gay MSM were more likely to have attained a college degree than their heterosexual and bisexual counterparts. They were also more likely to have private health insurance and were less likely to report higher poverty. Self-identified bisexual men, bisexual MSM, and heterosexual MSM were more likely to report higher poverty. Self-identified heterosexual men and heterosexual MSW were more likely to report at-risk drinking.

Aim 2: Disparities in Food Insecurity

Food Insecurity in Women. Weighted bivariate analyses indicated disparities in food insecurity for SMW no matter how sexual orientation was defined (Table 4.9), and these differences also persisted by sexual orientation subgroup (e.g., lesbian or bisexual vs. heterosexual). Adjusted logistic regression models (Table 4.10) indicated that the magnitude of effect differed by how sexual orientation was defined and sexual orientation subgroup. No matter how sexual orientation was defined, lesbians and lesbian WSW evidenced disparities in food insecurity—even when controlling for poverty and health insurance status. When sexual orientation was defined by sexual identity, compared to heterosexual women, lesbians were 87% more likely to report food insecurity (aOR = 1.87; 95% CI, 1.10-3.19) and bisexual women were 67% more likely to report food insecurity (aOR = 1.69; 95% CI, 1.15-2.51). However, when sexual orientation was defined in terms of sexual identity and lifetime sexual behavior, all sexual orientation subgroups evidenced disparities in food insecurity compared to heterosexual WSM (lesbian WSW: aOR = 1.99; 95% CI, 1.10-3.61; bisexual WSW: aOR = 1.79; 95% CI, 1.19-2.68; heterosexual WSW: aOR = 1.56; 95% CI, 1.08-2.62). Fewer disparities in food insecurity were evidenced when sexual orientation was defined in terms of sexual identity and 12-month sexual behavior; however, lesbian WSW were over twice as likely to report food insecurity than heterosexual WSM (aOR = 2.20; 95% CI, 1.11-4.36).

Severe Food Insecurity in Women. Sensitivity analyses indicated disparities in severe food insecurity for subgroups of SMW, even when controlling for economic covariates (Table 4.11). When sexual orientation was defined by sexual identity, lesbians were 4% more likely to report severe food insecurity that heterosexual women (aOR = 1.04; 95% CI, 1.01-3.73). The magnitude of the effect was greater for bisexual women, who were 86% more likely to report severe food insecurity than heterosexual women (aOR = 1.86; 95% CI, 1.27-2.72). When sexual orientation was defined by sexual identity and lifetime sexual behavior, lesbian WSW, bisexual WSW, and heterosexual WSW were more likely than heterosexual WSM to report severe food insecurity (lesbian WSW: aOR = 2.2; 95% CI, 1.11-4.40; bisexual WSW: aOR = 1.86; 95% CI, 1.20-1.87; heterosexual WSW: 2.01; 95% CI, 1.34-3.01). No disparities in severe food insecurity were evidenced when sexual orientation was defined by sexual identity and 12-month sexual behavior.

Food Insecurity in Men. While weighted bivariate analyses indicated disparities in food insecurity for SMM no matter how sexual orientation was defined (Table 4.9), adjusted logistic regression models only evidenced disparities in food insecurity for gay men and gay MSM (Table 4.10). When sexual orientation was defined by sexual identity, gay men were over twice as likely as heterosexual men to report food insecurity (aOR = 2.13, 95% CI, 1.31-3.76). Similarly, when sexual orientation was defined by sexual identity and sexual behavior (lifetime or 12-month), gay MSM were over twice as likely to report food insecurity than heterosexual MSW (lifetime: aOR = 2.17; 95% CI, 1.22-3.84; 12-month: aOR = 2.09; 95% CI, 1.18-3.69).

Severe Food Insecurity in Men. Similar results were identified in sensitivity analyses such that gay men and gay MSM were more likely to report severe food insecurity than their heterosexual counterparts, even when controlling for poverty and health insurance status (Table 4.11). When sexual orientation was defined by sexual identity, gay men were over thrice as likely to report severe food insecurity than heterosexual men (aOR = 3.04; 95% CI, 1.56-6.05). Similarly, when sexual orientation was defined in terms of sexual identity and lifetime sexual behavior, gay MSM were over thrice as likely as heterosexual MSW to report severe food insecurity (aOR = 3.08; 95% CI, 1.55-6.13). However, when sexual orientation was defined in terms of sexual identity and 12-month sexual behavior, the magnitude of effect was smaller where gay MSM were only 2.64 times as likely as heterosexual MSW to report severe food insecurity (aOR =2.64; 95% CI, 1.23-5.69).

Discussion

Aim 1: Food Insecurity and Current Smoking

Sexual minority women and men evidence consistent and substantial disparities in cigarette smoking.[2-7,9,10] Compared to heterosexual adults, lesbian and bisexual women are 50-350% more likely to report current smoking[2-7,9,10] while gay and bisexual men are 50-240% more likely.[2,4-6] While researchers have begun to investigate factors that might be driving these disparities, most focus on demographic[22-26] or psychosocial factors, including mental health[25,26] and alcohol[22,23,25,26] or other drug use.[22,23] However, these studies do not wholly explain cigarette smoking disparities among SMW and SMM,[25,26] and their individual-level focus overlooks upstream factors that may also influence smoking in these populations.

Food insecurity is an understudied, upstream factor associated with smoking in the general population; however, there is no published evidence of how food insecurity may contribute to smoking behaviors in SMW and SMM. To address this gap, and further our understanding of determinants of smoking in SMW and SMM, this study used population-level data to examine associations between food insecurity and smoking behaviors in SMW and SMM.

Results indicated significant associations between food insecurity and current smoking for SMW when sexual orientation was defined in terms of sexual identity and lifetime sexual behavior. SMW reporting food insecurity were 70% more likely to currently smoke than food secure SMW. However, sensitivity analyses did not evidence associations between severe food insecurity and current smoking in SMW. Among SMM, food insecurity was not associated with current smoking. However, in sensitivity analyses, SMM reporting severe food insecurity (vs. food security) were 272% more likely to report current smoking when sexual orientation was defined in terms of sexual identity and lifetime sexual behavior. Our results are consonant with the literature investigating food insecurity and smoking in the general population. In studies using comprehensive measures of food security, adults reporting food insecurity (vs. food security) are 54-377% more likely to report current smoking.[28,31,37]

In our study, both food insecurity and severe food insecurity were associated with smoking a greater number of cigarettes daily in SMW, when sexual orientation was defined in terms of sexual identity and sexual behavior (lifetime or 12-month). Among SMW who engaged in lifetime same-sex behavior, food insecurity (vs. food security) was associated with smoking 33%

more cigarettes daily whereas severe food insecurity (vs. food security) was associated with smoking 29% more cigarettes daily. Associations were more pronounced in SMW when sexual orientation was defined in terms of sexual identity and 12-month sexual behavior: On average, food insecure SMW smoked 82% more cigarettes daily than food secure SMW. Similarly, SMW experiencing severe food insecurity reported smoking 62% more cigarettes per day than food secure SMW. No associations between food insecurity/severe food insecurity and smoking intensity were evidenced for SMM, no matter how sexual orientation was measured. No published studies have investigated the association between food insecurity and smoking intensity, as defined by number of cigarettes smoked per day. However, in a study of low-income young adults, respondents reporting food insecurity were 91% more likely to report being a daily smoker than their food secure counterparts.[37]

Notably, food insecurity was more likely to be associated with current smoking and smoking intensity in SMW than SMM. This may be an artifact of sample size as approximately twice as many women than men identified as sexual minorities and/or reported engaging in same-sex sexual behavior. However, fundamental cause theory suggests that inequitable social conditions arising from structural discrimination disproportionally deplete the social and economic resources available to minority groups, leading to poor health behaviors and outcomes.[85] The intersection of sexism and heterosexism may thus place SMW at greater risk for experiencing structural discrimination and depletion of resources. In the absence of resources (e.g., experiencing food insecurity), SMW may be at greater risk for engaging in poor or risky health behaviors—including smoking.

Few differences in smoking behaviors were evidenced between subgroups of SMW and SMM, accounting for food insecurity, poverty, and health insurance status. However, when sexual orientation was defined by sexual identity and sexual behavior (lifetime or 12-month) gay MSM reported smoking 33-62% less cigarettes per day than heterosexual MSM. To our knowledge, only one population-level study has investigated smoking disparities in heterosexual MSM; however, no differences were found between heterosexual MSM and gay or bisexual MSM.[7] Our study may offer the first population-level evidence that heterosexual MSM differentially experience risk for smoking than their gay MSM counterparts. These results highlight the necessity of measuring sexual orientation across multiple dimensions as a foundational step in understanding vulnerability within groups of SMM. Further studies that investigate smoking

prevalence in heterosexual MSM and determinants of smoking disparities in this group are warranted.

Explaining the Association Between Food Insecurity and Smoking

Understanding how food insecurity is associated with smoking may help researchers design targeted interventions to reduce smoking in SMW and SMM. This study examined associations between food insecurity and current smoking, nicotine dependence, and smoking intensity. Importantly, we identified associations between food insecurity and smoking behaviors that existed independently of economic covariates. These results suggest that food insecurity/severe food insecurity uniquely contributes to current smoking (in SMW and SMM) and smoking intensity (in SMW only) beyond associations between poverty, health insurance, and smoking status.

One possible explanation for the association between food insecurity and current smoking is that the unique experience of food insecurity places excess stress upon food insecure individuals, thus, increasing the likelihood of smoking for stress relief. Longitudinal studies of psychological distress and smoking evidence mixed results, such that uptake of smoking is associated with psychological distress in the general population (i.e., smoking → psychological distress).[86,87] However, among women, baseline psychological distress is associated with uptake of smoking (psychological distress → smoking).[87]

Given significant results for women in our study, it could be that SMW are more likely to experience intersectional oppression and discrimination related to both their gender and sexual orientation. This concept is best articulated in studies of Black women's health.[88-90] In these studies, intersectional oppression conferred by race and gender is labeled "gendered racism" such that Black women are theorized to experience unique oppression and discrimination due to their interlocking identities as Black and female.[91] Experiencing gendered racism is associated with psychological distress in Black women.[88,92]

For SMW, minority stress theory posits that individual who hold multiple minority identities (e.g. gender and sexual orientation) experience multiplicative disadvantage that arises from interlocking, systemic discrimination and oppression.[89,93,94] For example, in the U.S., heterosexuality and male gender confer privilege and power. Accordingly, sexual minority women are afforded less privilege and power. For example, lesbian women may face sexism,

heterosexism and homophobia in society at-large, as well as sexism in sexual minority communities. When combined with food insecurity, this “gendered heterosexism” may disproportionately burden SMW. As such, food insecure SMW may experience excess stress that engenders smoking behaviors. However, longitudinal cohort studies of SMW using comprehensive measures of food insecurity, smoking, and stress across multiple time points are needed to investigate this hypothesis.

A second explanation is that smoking is a coping strategy using by food insecure people to manage hunger. Among populations of food insecure women, limiting number of meals and skipping meals entirely are regularly documented strategies for coping with food insecurity.[95-98] It is possible that food insecure SMW smoke to manage hunger due to intentionally skipping meals. Using smoking to manage hunger is documented among women in the general population; however, most of this evidence comes from a literature on weight control where women report using cigarettes as a coping strategy when intentionally fasting[99,100] or restricting calories.[101] Nonetheless, there is emerging evidence in the qualitative literature that low-income individuals may use smoking to cope with hunger. Low income pregnant women report smoking as a coping strategy for managing hunger and saving money on food.[102] This is similar to data from interviews with Native American women who report smoking to stave off hunger.[103] This “hunger hypothesis” is also supported by a recent qualitative study with food insecure transgender people where participants reported smoking to alleviate hunger.[104] Taken together, these studies suggest that food insecure SMW may use smoking as a tool to manage hunger. This may explain associations between food insecurity and smoking behaviors in this study.

A further explanation for the association between food insecurity and smoking is that smoking may be more socially acceptable in food insecure sexual minority adults. A recent systematic review indicated that smoking is normalized within low-income communities in the general population.[105] SMW and SMM may also normalize smoking. In a qualitative study with community leaders in New York City, interviewees noted described smoking as a tool that allows SMW and SMM to come together in like groups across differing social environments. Similarly, sexual minorities located in low-income areas of Appalachia, cite social acceptance of smoking by peers and the desire to “fit in”—even in the absence of peer pressure—as primary motivations for smoking.[106] This social aspect of smoking is cited in multiple studies as a barrier to quitting, as sexual minority smokers fear losing access to social circles if they quit.[106-108] SMW and SMM’s desire for social acceptance and inclusion makes sense, as social isolation and

exclusion from society-at-large is a documented concern for sexual minorities across the lifecourse.[109-113] Maintaining access to supportive social networks may, thus, outweigh health consequences associated with smoking. Given the results indicated in our study, it may be that intersecting poverty and sexual minority identities increase risk for socially-reinforced smoking, which is then compounded by experiences of food insecurity. However, qualitative research examining the lived experiences of low income, food insecure, sexual minority people—and especially SMW—is needed to better understand these associations.

Finally, a persisting explanation for the association between food insecurity and smoking is that food represents an "opportunity cost" such that smokers forgo purchasing food to purchase cigarettes.[32,33] Studies in the general population suggest that low income smokers are less likely to reduce cigarette consumption when faced with cigarette price increases.[114,115] As such, low income people who smoke may become food insecure as a greater proportion of income is needed to buy cigarettes due to rising tobacco taxes. Qualitative research supports this hypothesis. In a qualitative study of low-income smokers in Australia, participants reported that cigarettes were a "protected" or "priority" purchase. As such, they regularly used food deprivation strategies—including skipping meals—as a means to afford cigarettes. Termed "smoking-induced deprivation" (SID), the phenomenon of spending money on cigarettes at the expense of food or other necessities is more prevalent in young adult (vs. < age 55), racial/ethnic minority (vs. white), and low income (vs. high income) smokers.[116] In this scenario, food insecure adults smoke as a means to manage stress. Cross-sectional studies indicate an association with stress, such that reporting a high level of perceived stress is associated with a 6% increase in reporting SID.[116] This evidence is supported qualitatively, where low income smokers report that stress related to poverty status reinforced SID where the short-term reward of smoking was deemed as a preferable to managing stress from competing financial responsibilities without smoking.[114] Given that our study used cross-sectional data, it is possible that we misspecified our model such that smoking actually gives rise to food insecurity through SID strategies. Longitudinal studies examining bidirectional associations between food insecurity and smoking in SMW and SMM are needed to address this question.

Aim 2: Sexual Minority Disparities in Food Insecurity

In addition to examining associations between food insecurity and smoking in SMW and SMM, to our knowledge, this is the first study to investigate food insecurity disparities in populations of women and men using a comprehensive, USDA-endorsed measure of food security and

multiple measures of sexual orientation. The original disparities report from the Williams' Institute indicated that more LGBT women (vs. non-LGBT women) and LGBT men (vs. non-LGBT men) reported not having enough money to buy food (women: 34% vs. 20%, $p < .05$ and men: 25% vs. 16%, $p < .05$). However, results were not examined in multivariable analyses controlling for covariates, nor were differences by sexual orientation subgroup considered.[39]

By stratifying analyses by gender and defining sexual orientation by sexual identity as well as in terms of sexual identity and sexual behavior, we were able to identify disparities across diverse sexual minority subgroups (e.g., heterosexual WSW, lesbian WSW, and bisexual WSW vs. heterosexual WSM). As such, our results extend the extant literature. Our results indicated food insecurity disparities for multiple subgroups of SMW, regardless of how sexual orientation was defined. When sexual orientation was defined solely by identity, both lesbian and bisexual women were more likely to report food insecurity (aOR = 1.87 and aOR = 1.69, respectively) than heterosexual women. These disparities persisted when we examined associations between sexual orientation and severe food insecurity; however, the magnitude of effect was smaller. Lesbian and bisexual women were significantly more likely to report severe food insecurity (aOR = 1.04 and aOR = 1.86, respectively) than heterosexual women.

When sexual orientation was defined in terms of sexual identity and lifetime sexual behavior, we revealed disparities for previously hidden subgroups of SMW. Heterosexual WSW, lesbian WSW, and bisexual WSW were all more likely to report food insecurity when compared to heterosexual WSM (aOR = 1.99, aOR = 1.79, and aOR = 1.56, respectively). Similar results were evidenced in sensitivity analyses; however, the magnitude of effect increased such that heterosexual WSW and lesbian WSW were over twice as likely to report severe food insecurity than heterosexual WSM.

Analyses also indicated disparities in food insecurity for gay men when sexual orientation was defined by sexual identity (aOR = 2.13; vs heterosexual men), in terms of sexual identity and lifetime sexual behavior (aOR = 2.17; vs. heterosexual WSM), or in terms of sexual identity and 12-month sexual behavior (aOR = 2.91; vs. heterosexual WSM). These disparities persisted when food insecurity was defined more narrowly as only the sample of people experiencing severe food insecurity.

It is important to note that our results differ from those presented in a later Williams Institute report where significant differences in food security were not indicated between sexual minority and heterosexual adults in bivariate analyses (12% vs. 11%, p = n.s.) nor multivariable models (aOR = 1.19, p = n.s.).[38] Gender-based analyses also did not produce significant differences.[38] While this study used a comprehensive measure of food insecurity, respondents were asked to report only on past 30-day experiences.[38] In the general population, approximately 9% of households report past 30-day food insecurity; however, over 16% report experiencing food insecurity over the past 12 months.[34] On average, food insecure households experience food insecurity for 7 months out of the year; as such, surveys using 30-day recall periods may underestimate food insecurity disparities.[34] By using a comprehensive measure of food security with a 12-month recall period, our study depicts the extent of food insecurity disparities experienced annually by SMW and SMM.

Explaining Food Insecurity Disparities in SMW and SMM

Food security is defined as "access at all times" to enough food to lead an active healthy lifestyle. Even though poverty and type of health insurance were both strongly associated with food insecurity, subgroups of SMW and gay men evidenced disparities in food security independently of economic predictors. One hypothesis for these disparities is that SMW and gay men have less access to coping resources that alleviate food insecurity in the general population. In the qualitative literature, food insecure adults identify multiple coping strategies for maintaining food sufficiency. These include participating in state and federal food or income assistance programs (e.g., Supplemental nutrition assistance program [SNAP]; Women, infants, and children [WIC], Temporary assistance for needy families [TANF]), accessing local food programs (e.g., food pantries, soup kitchens, shelters) or events (e.g., church fellowships), seeking money or food from family members/friends, using credit to buy food, seeking additional employment (and especially through "under the table" work), hunting and foraging for food, shopping from low cost venues, and stealing food.[98]

Scholars argue that an individual's social position—and associated power—shape the strategies they use to alleviate food insecurity.[117] Food insecure adults in the general population report food pantries as a primary strategy for coping with food security.[118] In 2017, compared to 1.8% of the general population of food secure households, more households with low (20.9%) or very low (34.2%) food security reported using food pantries.[119] Similarly compared to 0.2% of food

secure households, more households with low (1.9%) or very low (5.5%) food security reported using soup kitchens.[119]

However, food pantries may not be an accessible food source for SMW and gay men. Regional studies suggest that many community-based assistance programs are religiously affiliated.[120-124] The integration of food pantries with religious organizations may present a barrier for sexual minorities who may be less likely to access religiously-affiliated food pantries due to fear of experiencing spiritual violence (i.e., hatred and discriminatory practice against SMW and SMM due to religious-associated immorality[125]). To our knowledge, no studies have explicitly investigated the experiences of SMW and SMM who access food pantries. However, in a recent qualitative study of food insecure transgender and gender non-conforming (TGNC) individuals, respondents were less likely to seek food assistance in their local communities due to fear of gender- and sexual orientation-based stigma and discrimination from religiously-affiliated food pantries.[104] In their criticism of the privatization of social services, Blackwell and Dziegielewski (2005) suggest that by funding religious organizations to provide social services, including food assistance, the U.S. government creates access barriers for sexual minorities.[125] Indeed, there are no explicit protections for SMW and SMM seeking community-based food assistance. Moreover, recent “religious freedom” laws allow businesses—including food pantries—to deny service to sexual minorities based on moral and religious convictions.[126,127] Without equitable access to community-based food sources, SMW and SMM may be at even greater risk for food insecurity than heterosexual women and men.

It may also be that SMW and SMM are less likely to rely on nuclear family networks to cope with food insecurity. In the general literature, reliance upon nuclear family for sources of cash or food assistance is common in low income, food insecure populations.[95-98,118,128,129] This may not be possible for SMW and SMM, who may experience rejection from nuclear family due to sexual orientation-related stigma and discriminations. In lieu of family support, SMW and SMM may turn to “chosen family” or friendship networks for cash or food assistance to alleviate food insecurity. The role of families of choice in providing economic and in-kind supports is documented in lesbians, gay, men, and older sexual minority adults.[130-132] More recently, Russomanno et al. (2018) determined that relying on families of choice was a coping strategy used to increase food access by food insecure TGNC people who did not have nuclear family supports. Similar strategies may be employed by SMW and SMM.

Sexual minority people may also turn to online networks to cope with foods insecurity. Online social networks (e.g., Facebook) have spurred the creation of “food sharing” groups for LGBT people. In these online spaces, group members can proactively ask for food donations or respond when food is offered by group members.[133] As online LGBT food-sharing networks are community-driven, they may be effective in increasing food access while decreasing stigma associated with food insecurity. They may also offer a sense of safety to LGBT group members who may be afraid to access local food pantries due to perceived or experienced discrimination. However, no comprehensive resource documents these networks, and they may be difficult for some SMW and SMM to find. For example, in rural areas with limited infrastructure (e.g., access to transportation, internet), it may be more challenging for SMW and SMM to connect with online social resources or meet people in-person to exchange food.

Multiple studies document the use of food assistance programs in low-income families struggling with food insecurity.[95-98,128] SNAP is distributed by federal and state governments to low income families that meet specific poverty thresholds.[134] SNAP aims to increase recipients’ self-sufficiency and reduce hunger by facilitating access to food. Studies indicate that SMW and SMM are 30-70% more likely to receive SNAP benefits than heterosexual adults.[38,39] This is important because longitudinal evidence indicates that SNAP utilization is associated with a 31.2% decrease in households reporting food insecurity and 20.2% decrease in households reporting severe food insecurity over 6 months.[135,136] Given SMW and SMM’s higher use of SNAP, future studies should investigate whether receiving food assistance reduces food insecurity disparities in SMW and SMM.

Gender-based Food Insecurity Disparities

No matter how sexual orientation was defined, SMW were more likely to experience food insecurity than SMM. One explanation is that SMW experience intersectional oppression due to their multiple minority identities (i.e., gender and sexual orientation). Minority stress theory suggests that intersecting marginalized identities (i.e., gendered heterosexism) may increase SMW’s experiences of structural discrimination. Applying fundamental cause theory, the greater structural discrimination experienced by SMW disproportionately depletes their social and economic resources, which may increase their susceptibility to food insecurity in comparison to SMM. Evidence supports this hypothesis. In their report on poverty, Badgett et al. (2013) suggest that SMW face economic challenges arising from employment discrimination, lower insurance rates, and historical lack of access to tax and financial benefits associated with

marriage.[137] While minimal research has documented experiences of poverty in SMW, the existing studies indicate that more SMW than heterosexual women are poor or near poor.[137,138] These disparities are further exacerbated for SMW of color[139] and rural SMW,[137] which supports our hypothesis that intersectional oppression may further diminish SMW's access to economic and social resources. Decreasing food insecurity for SMW, thus, requires not only addressing inequitable social conditions specific to sexual orientation, but also those that produce structural discrimination respective to gender and intersecting minority identities (e.g., race/ethnicity).

Strengths

This study has multiple strengths. To our knowledge, this study provides the first evidence for food insecurity as an independent predictor of cigarette smoking in sexual minority populations. This is important because most research to date has focused on how individual-level demographic (e.g., age, race/ethnicity) and psychosocial characteristics (e.g., poor mental health, alcohol use) predict smoking behaviors with resulting recommendations being to direct individual-level interventions to at-risk demographic communities. Yet, health equity research requires that researchers move beyond individual-level risk factors to identifying "upstream' social determinants of health (e.g., social, policy, and economic factors) that may be intervened upon at a population level. Our results suggest that food insecurity is associated with smoking behaviors—in SMW especially—thus, pointing researchers to further examine how community- and policy-level solutions to decrease food insecurity may alleviate smoking in this group.

This study also provides the first evidence of food insecurity disparities in SMW and SMM, using multiple measures of sexual orientation and a comprehensive measure of food security. Our results reveal previously unknown disparities in diverse subgroups of SMW—including heterosexual WSW—and provides further evidence that how we measure sexual orientation influences what we know about sexual minority health disparities.

Moreover, by embracing an intersectionality framework and examining gender-based differences in food insecurity and smoking, our study also indicates a gender effect. SMW in our study were more likely to evidence food insecurity and smoking disparities than SMM. This may suggest that SMW are exposed to greater structural discrimination than SMM due to gendered heterosexism. Alternatively, it could be that SMW experience greater social and economic resource loss (i.e., increased food insecurity) in the face of structural discrimination. At the individual-level, it could also be that SMW cope differently with structural discrimination and

resource loss, leading to greater risk behaviors (i.e., smoking). Future studies investigating multilevel social determinants—including gendered heterosexism—are needed to address this question.

Population-based studies of sexual minority health disparities are plagued by small sample sizes,[62,63] which limit our ability to adequately power analyses while controlling for sources of confounding. Moreover, modern epidemiological methods indicate that regression models which include unnecessary covariates may introduce bias into analyses.[64] Consequently, novel, empirically-based methods that preserve power while controlling for bias are needed to further epidemiological research in sexual minority health. To address these concerns, our study introduced working models of DAGs to empirically inform covariate selection.[66,67] To this end, we mapped a priori assumptions about directional relationships between variables of interest, which allowed us to identify sources of confounding and determine minimally sufficient covariate sets to include in regression models. In doing so, we were able to refrain from overadjustment, minimize sources of bias, and preserve power in regression analyses. Moreover, by transparently mapping our model assumptions, we provide more data to which researchers can respond, replicate, and extend our study findings.

Limitations

This study is not without limitations. While our intent was to reduce the likelihood of confounding by using a working DAG to guide our analyses, even with accurate specification of causal associations, DAGs still produce residual confounding. One concern when using cross-sectional data is that we cannot predict the direction of causality between variables, nor can we be fully sure that we have correctly specified the model such that all potential and relevant confounders are included. Unmeasured and unidentified covariates might create confounded pathways between the exposure and outcome. However, by using theoretically and empirically informed models, we reduce the likelihood of over-specifying covariates and inadvertently including confounding variables in our analytic models. It is important to note, however, that even with correct model specifications, all studies experience measurement error. Even if we adjust for a variable, we cannot ensure that we are measuring the covariate in a manner that fully removes that variable's effect on the association between exposure and outcome.[140] For example, as discussed in previous publications,[16] NHANES' sexual identity measure pairs each identity response (e.g., "lesbian with a statement about sexual attraction (e.g., "sexually attracted to females"). Such double-barreled questions may conflate responses as individuals must choose

a single response that comprises multiple aspects of their sexual orientation in a single question. In this study, we used NHANES' sexual identity/attraction question as a proxy for measuring sexual identity. However, theory tells us that attraction and identity may not always appear to be concordant.[141] Measuring multiple dimensions of sexual orientation allows us to identify individuals (e.g., those who do not identify as SMW/SMM but experience same-sex attraction) who may also experience health disparities. However, failing to measure multiples dimensions of sexual orientation—or misspecifying sexual orientation measures with double-barreled questions—limits our ability to identify and investigate health risks in these groups.

Previous studies have defined sexual minority adults in terms of identity and lifetime sexual behavior.[16,19,142] While this definition allows researchers to identify hidden subgroups (e.g., heterosexual MSM), it may capture individuals who self-identify as heterosexual who have engaged only in few lifetime same-sex behavioral experiences and, thus, are less likely to experience sexual orientation-related minority stress than self-identified heterosexuals who consistently engage in same-sex behavior. To address this concern, we also defined sexual orientation in terms of identity and past 12-month sexual behavior. This definition may capture individuals who have more recently experienced sexual orientation-related discrimination and resulting loss of social and economic resources hypothesized to contribute to health disparities. However, even pooling 10 years of data, this operationalization of sexual orientation produced substantially small samples of SMW and SMM. These sample sizes for SMM, specifically, may have precluded our ability to detect an effect between food insecurity and smoking.

More generally, a considerable number of respondents did not complete the NHANES' sexual behavior questionnaire, which may influence food insecurity and smoking estimates in sexual minority populations. Respondents who do not complete the sexual behavior questionnaire may have experiences with food insecurity or smoking different than respondents completing this module.

We did not include individuals who responded to sexual identity questions as "something else", "other", "don't know", or "refused" in this study. Best practices for studying sexual minority health disparities caution against including respondents who refuse to answer sexual orientation questions due to potential confounding.[46] While we considered running analyses that included subgroups of individuals who identified as "something else" or "other" to sexual identity questions, preliminary analyses indicated that subgroups would be too small to produce

meaningful estimates when sexual orientation was defined in terms of sexual identity and sexual behavior. Generally, even pooling 10 years of data, our sample sizes for SMW and SMM were small. Small sample sizes limit the complexity of analyses and the statistical power to examine heterogeneity within SMW and SMM. One strategy, which we employed in our analyses, is to use DAGs to identify MSAs for estimating direct effects. A second strategy is to increase sample sizes of underrepresented groups via oversampling, however, this practice is not currently used in health surveillance for sexual minorities.[45]

Finally, NHANES asks sexual orientation questions only for women up to age 59 and for men up to age 69 (for 12-month sexual behavior). This is problematic because sexual orientation is salient across the lifecourse and older adults differentially experience food insecurity (increased in older adults) and smoking (decreased in older adults). Consequently, estimates of associations between food insecurity and smoking may differ in subgroups of older SMW and SMM. Future studies must include sexual orientation measures for older adults (>age 60), so that we can more accurately identify food security disparities and understand associations between food insecurity and smoking behaviors in SMW and SMM across the life course.

This study is rooted in the premise that unidimensional sexual orientation measurement is not sufficient for identifying groups of SMW and SMM at high-risk for disparities. In that sense, this study embraces an intersectionality framework that investigates smoking and food insecurity disparities in populations defined at the intersection of gender and sexual orientation. However, the premise of fundamental cause theory is that social determinants—including structural discrimination via social, economic, and policy resources—drive persistent, disparate health outcomes in multiple historically-oppressed groups.[85,143,144] These groups—defined by gender, race/ethnicity, sexual orientation, socioeconomic status, ability, geographic location, etc.—experience intergenerational, historical, and contemporary oppression and discrimination. As such, health equity and sexual minority health researchers must investigate health disparities that occur at the intersection of these identities. Due to small sample sizes and the low prevalence of food insecurity in the general population, we were unable to investigate differences in diverse groups of SMW and SMM defined by marginalized identities beyond gender and sexual orientation. This is a substantial limitation of our study and the field in general.[62,145]

Implications and Future Directions

Our study is the first to investigate how food insecurity contributes to smoking disparities in SMW and SMM. Results indicate that food insecure SMW and gay men are more likely to report current cigarette smoking and smoking more cigarettes per day than their food secure counterparts. These smoking disparities place food insecure SMW and gay men at disproportionate risk for developing tobacco-related cancers and chronic disease.[12] As such, smoking cessation interventions designed to overcome barriers to cessation faced by these groups are needed to reduce smoking and, ultimately, tobacco-related chronic disease.

Evidence from community-based studies indicates that universal smoking cessation programs may need tailoring to address the unique experiences of oppression, discrimination, and stress experienced by SMW and SMM as contributing factors to smoking.[146-151] Specifically, LGBT-specific smoking cessation programs may be more likely to produce successful quitting in SMW and SMM by facilitating community-specific coping strategies and social supports.[146-149] However, the extant literature is limited in its review of the effectiveness of smoking cessation programs in food insecure or low income SMW and SMM. As such, descriptive studies investigating the unique cessation needs of food insecure smokers may be warranted. Once the needs of food insecure SMW and SMM smokers are known, studies testing the efficacy of successful LGBT-specific cessation programs tailored to these populations are warranted.

It is important to note that studies testing existing LGBT smoking cessation programs have been limited to urban settings and in-person participation. As such, food insecure SMW and SMM—especially those located in rural and conservative areas—may have less access to LGBT-friendly, smoking cessation resources. To address this concern, mHealth smoking cessation interventions that capitalize on mobile apps, text-based, online forums, or social media platforms may be more effective in reaching these underserved and vulnerable subpopulations of SMW and SMM. Feasibility studies testing mHealth cessation interventions are needed to establish acceptability, feasibility, and preliminary efficacy with food insecure SMW and SMM smokers.

Our study suggests that decreasing smoking disparities in SMW and SMM also requires addressing food insecurity disparities in these populations. Several multilevel community-based and policy solutions may be implemented to reduce food insecurity in SMW and SMM. At the local level, increasing access to LGBT-friendly, local food sources is imperative for decreasing

food insecurity for SMW and SMM. One solution is the rise of LGBT-specific food pantries sponsored by community-based organizations. In major metropolitan areas, including New York City,[152], Chicago,[153] and Los Angeles,[154] LGBT organizations are taking on food access as an issue and sponsoring food pantries and hot meals. These programs may target vulnerable populations, including older LGBT adults[152,154] or those living with HIV/AIDS.[152] However, it is unclear how many food insecure SMW and SMM know about or access these pantries. Additionally, it is unknown whether such food pantries exist in rural and conservative areas where LGBT community-groups may be less likely to own brick-and-mortar spaces due to infrastructure issues or community stigma. As such, existing LGBT food pantries may not be accessible to vulnerable subgroups of SMW and SMM. Mixed-methods studies investigating local factors that exacerbate and alleviate food insecurity for SMW and SMM (e.g., food pantries, community networks, and individual-level coping strategies) may inform the improvement of existing food pantries or development of newer methods. These may include locally organized food sharing communities via online social platforms that proactively engage vulnerable, food insecure SMW and SMM.

Policy solutions require addressing structural determinants that give rise to food insecurity in SMW and SMM. One area of concern is the rise of state-level religious freedom restoration acts (RFRAs or “religious freedom laws”) across the United States.[126,127] In states with religious freedom laws, SMW and SMM are not protected against sexual orientation-based discrimination in public accommodations—including faith-based food pantries. To date, 27 states do not have laws that explicitly prohibit sexual orientation-related discrimination in public accommodations.[155] All of these are located in federal circuits where appeals court decisions do not include sexual orientation as part of federal prohibitions on sex discrimination.[155] As such, SMW and SMM in these states do not have any legal protection against sexual orientation-related discrimination. Importantly, most of these states cluster in the South, Midwest, and Mountain regions of the United States[155]–areas where 22-34% of the population identify with evangelical Christian traditions that do not support homosexuality.[156] In a 2014 Pew report, 55% of Evangelical Christians believed that homosexuality should be discouraged and 64% opposed same-sex marriage.[156] Historically, many private food assistance programs (i.e., food pantries and soup kitchens) have been run by churches and faith-based nonprofits,[157] which SMW and SMM may be less likely to access out of fear of discrimination. As such, in addition to challenging state-level RFRAs, policy efforts aimed at increasing nondiscrimination protections

in these geographic areas are imperative to increase food pantry access for food insecure SMW and SMM.

It is not enough, however, to increase access to food pantries. To decrease food insecurity for SMW and SMM, we must address the broader determinants that give rise to economic instability for these groups. Many SMW and SMM are not protected in employment. To date, 26 states do not have state laws that prohibit sexual orientation-based employment discrimination.[155] Sixteen of these also do not have state laws prohibiting discrimination in public employment.[155] The lack of employee protections for SMW and SMM is concerning. A 2007 systematic review of sexual orientation-based employment discrimination determined that between 15-43% of SMW and SMM report workplace discrimination.[158] Discriminatory experiences ranged from termination due to their sexual orientation to being denied employment, denied promotion, and receiving poor performance evalautions.[158-160] While these estimates are changing over time, contemporary studies indicate that 1 in 5 LGBT workers feel that they were denied job opportunities because of their sexual orientation or gender identity (SOGI).[159] Alarmingly, 1 in 8 feel they could be fired because their workplace is not welcoming to LGBT people, and 1 in 10 have left jobs because they were not welcoming.[159] As evidenced through these studies, the culmination of employment discrimination results in destabilized employment histories and lowered wages for SMW and SMM,[158] which increases risk for poverty.

Preventing employment discrimination for SMW and SMM requires instituting federal and/or state laws that protect against sexual orientation-based employment discrimination. As aforementioned, most policies are state-based, creating a patchwork of employment protections for SMW and SMM across the U.S. More recently, a coalition of 180 businesses guided by the Human Rights Campaign (HRC) has pledged support for the federal Equality Act; legislation that would prohibit discrimination based on sex, sexual orientation, and gender identity across public accommodations, employment, housing, education, and federal funding.[161] While promising, the Equality Act has been re-introduced in Congress since 1974 and is yet to pass both the House *and* Senate.[161]

In the absence of policy reform, it is critical that employers adopt sexual minority-supportive workplace policies.[162] Over the past two decades, we have witnessed much progress in this policy area. Nearly all (91%) Fortune 500 companies have sexual orientation nondiscrimination

policies[160] and the HRC's Corporate Equality Index (CEI) indicates tremendous growth in the number of companies that support sexual minority workers.[163] For 17 years, the CEI has evaluated how businesses incorporate (1) LGBT non-discrimination policies, (2) equitable benefits for LGBT workers, and (3) LGBT-inclusive culture and corporate social responsibility. Over that time, the number of businesses receiving high rankings for promoting LGBT equality has grown from 13 to 572.[163] Despite this remarkable progress, few of these companies represent smaller, local or family-owned organizations. Studies indicate the importance of heteronormative "family values" as guiding principles in small, local, and family-owned businesses.[164] It may be that workplaces founded in "family values" are less likely to adopt LGBT-supportive policies; however, no published studies to date have addressed this issue. Policy measures that reduce poverty in low-income people in general would further support food insecure SMW and SMM. These may include policies to increase the minimum wage or expand the earned income tax credit (EITC).[165] Expansion of the EITC, which mostly benefits households with children, could greatly benefit SMW and SMM. Currently, adults without children or adults who do not have custody of children they are raising, but who work a full-time job at the federal minimum wage, do not qualify for EITC benefits. For low income SMW and SMM, who may be less likely to be raising an EITC-*qualifying* child,[166] current income taxation policies may further increase poverty.

Specific SNAP-related policies must also address vulnerable populations, including SMW and SMM. Recently, the USDA proposed changes to SNAP benefits such that able-bodied adults without dependents (ABAWD) having trouble securing employment would have limited access to SNAP benefits.[167] Currently, SNAP benefits are limited to 3 months in 3 years for ABAWD aged 18-49, without disabilities, and without dependent children if they do not work at least part-time (20 hours/week) or enroll in an employment training program.[167] However, states have authority to waive these limits for ABAWD who cannot meet work requirements. The proposed policy would restrict state-level authority to extend SNAP benefits by waiving work requirements for vulnerable, unemployed ABAWD.[167] Given workplace and hiring discrimination faced by SMW and SMM, the proposed changes to SNAP could disproportionately affect sexual minority adults. Moreover, it is likely the negative effect of these changes would be compounded in states that do not support non-discrimination laws, where poverty gaps are higher between heterosexual and sexual minority households with children.[168] Without SNAP access to supplement food supplies, it is possible that more SMW and SMM will experience food insecurity and negative sequelae, including cigarette smoking.

Conclusion

To our knowledge, this study is the first to investigate how food insecurity is independently associated with smoking behaviors in SMW and SMM. Food insecure and severely food insecure SMW and SMM were more likely to report current smoking. This may indicate that food insecurity is one upstream socioeconomic factor driving tobacco-related chronic disease disparities evidenced in these populations.[16-19] In SMW, experiencing food insecurity and severe food insecurity was also associated with smoking intensity, such that food insecure/severely food insecure SMW smoked more cigarettes per day on average than SMW who were food secure. This association is important because cigarette smoking exhibits a dose-response relationship with multiple chronic diseases for which SMW evidence disparities (i.e., arthritis, CVD, and stroke[16,18,57,169-171]). Given these results, observational studies that engage low income and food insecure SMW smokers are needed to understand the complex pathways between food insecurity and smoking. Once we understand how risk and protective factors influence smoking in food insecure SMW, we can then develop and test tailored cessation programs that engage food insecure SMW in successful quitting.

SMW and gay men in our study were more likely to experience food insecurity than heterosexual women and men, even when controlling for economic covariates. That SMW and gay men disproportionately experience food insecurity is concerning, as studies of chronic disease in the general adult population suggest that food insecurity is associated with diabetes[172] as well as hypertension and hyperlipidemia (both risk factors for cardiovascular disease).[173] However, these studies did not account for smoking in adjusted analyses. To understand how smoking influences associations between food insecurity and chronic disease, we must use innovative methods to identify causal pathways. These may include applying theoretically- and empirically-informed DAGs or structural equation models to test preliminary hypotheses using cross-sectional data. However, to truly understand the unique mechanisms that give rise to chronic disease disparities, we must develop and fund longitudinal, cohort studies that engage diverse groups of SMW and SMM.

This study also indicates that how we define sexual orientation matters for how we understand health disparities in SMW and SMM. While the gold standard for measuring sexual orientation requires that studies assess sexual identity, sexual behavior, and attraction—few population-based health surveillance programs include multiple measures of sexual orientation.[45]

Consequently, very little is known about prevalence or predictors of smoking in heterosexual WSW/MSM[7,61] and, to our knowledge, no published studies have assessed food insecurity disparities in these groups. However, our study suggests that health disparities vary across subpopulations of SMW and SMM. It may be that subpopulations of SMW and SMM differently experience risk factors for food insecurity and smoking (i.e., inequitable social conditions, minority stress, and depletion of social and economic resources). It is also plausible that subpopulations may experience entirely unique risk factors. For example, there is evidence that lesbians are less likely to conform to social expectations that normalize thinness and dieting;[174-176] thus, they may be less likely to encounter social messages supporting smoking as a means to control weight and hunger. To further our understanding of patterns and predictors of smoking disparities, where possible, public health surveillance programs must include more than one measure of sexual orientation. In addition, studies that engage diverse subgroups of SMW and SMM to investigate risk and protective factors for food insecurity and smoking are needed to develop and test tailored evidence-based interventions to decrease disparities.

Finally, this study adds to the mounting epidemiological literature that documents health disparities in SMW and SMM. While we know much about the broad categories of social, economic, and health disparities experienced by sexual minorities in general, gaps remain in our comprehension of multilevel mechanisms that give rise to these disparities. Concerted public health research, policy, and practice efforts are needed to better understand how social determinants—including inequitable social environments—drive disparities in SMW and SMM. Solutions include conducting longitudinal, mixed-methods observational studies that engage diverse sexual minority subgroups and measure multilevel determinants of health and related health outcomes. We can directly apply evidence from these studies to develop and test tailored disparities-reducing solutions. At the individual-level, these might include smoking cessation programs that engage low income and food insecure sexual minorities. At a community-level, solutions may include partnering with state- and local food assistance programs to embed smoking cessation programs into existing services, training staff at food assistance programs in LGBT cultural competency, encouraging the adoption of LGBT-inclusive policies in local food assistance programs, or developing LGBT-focused food sharing networks (in person or online). More broadly, we must direct state and federal policy efforts to increasing non-discrimination protections for SMW and SMM, limiting the protection of religious freedom laws within public accommodations, and decreasing poverty in general. It is only through coordinated, multilevel efforts to eliminate inequitable social conditions and increase access to social and economic

resources, that we will successfully improve individual- and population-level health for all SMW and SMM.

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Appendix. Figures and Tables

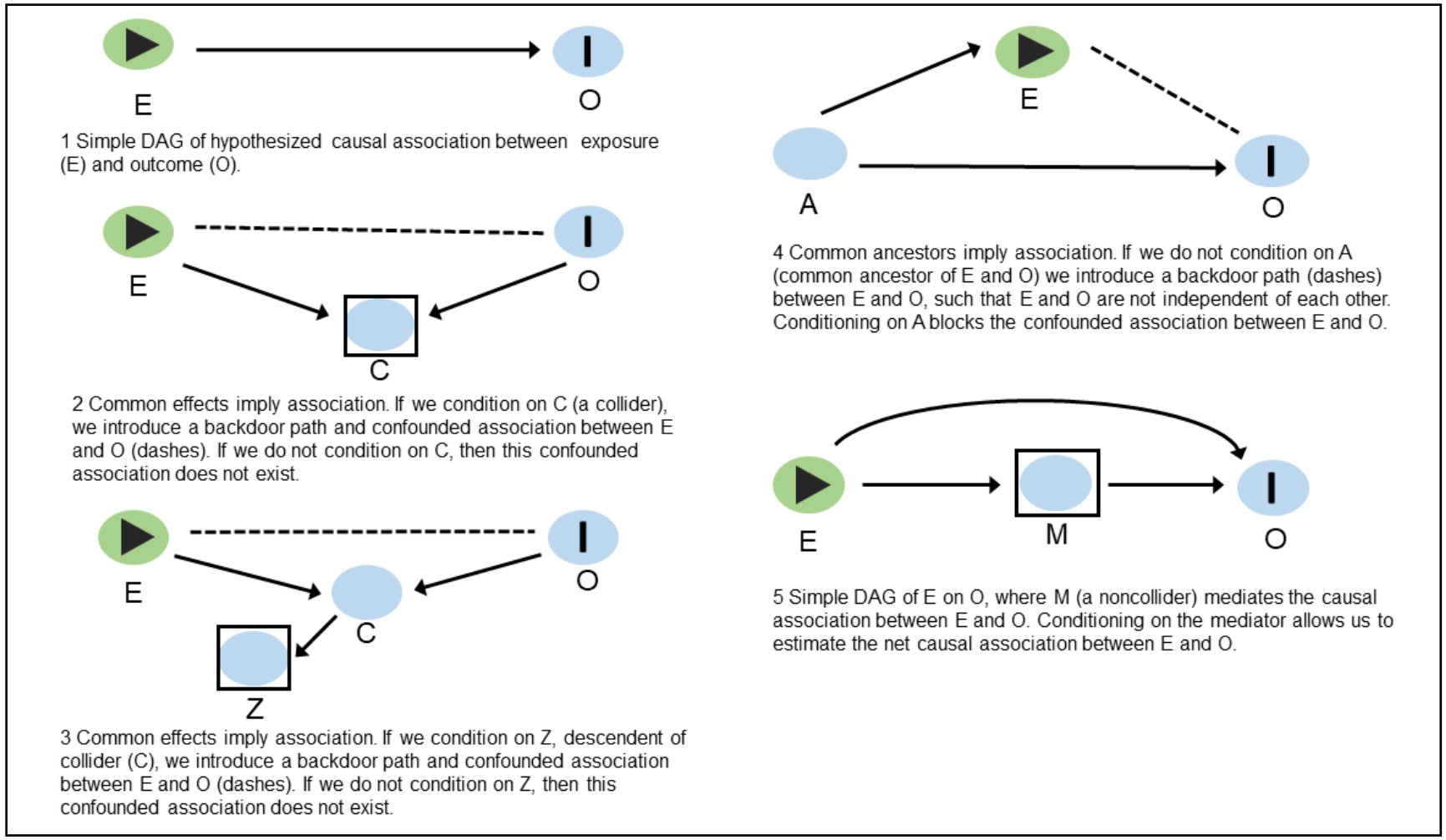

Figure 4.1 Examples of directed acyclic graphs (DAGs) demonstrating blocked and unblocked pathways between variables

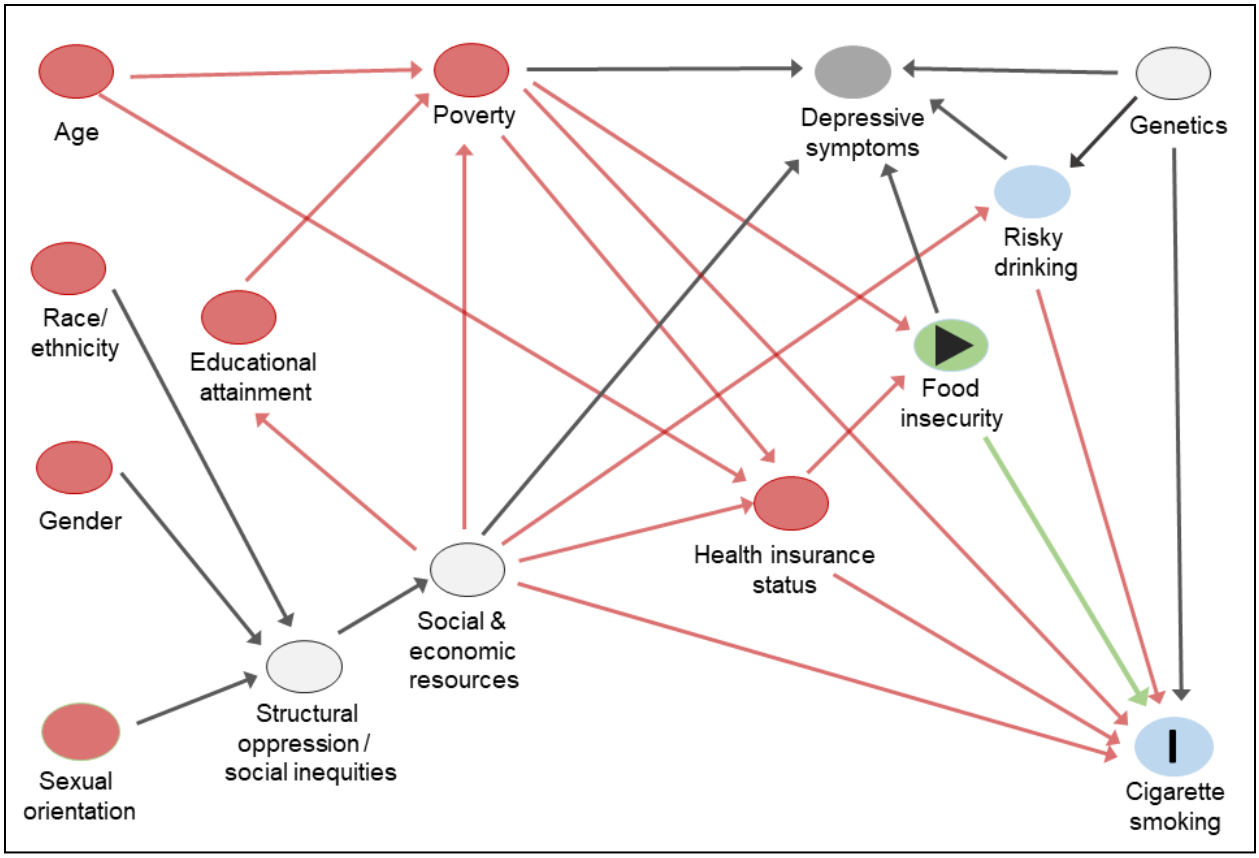

Figure 4.2 Working model depicting hypothesized pathways between food insecurity and cigarette smoking

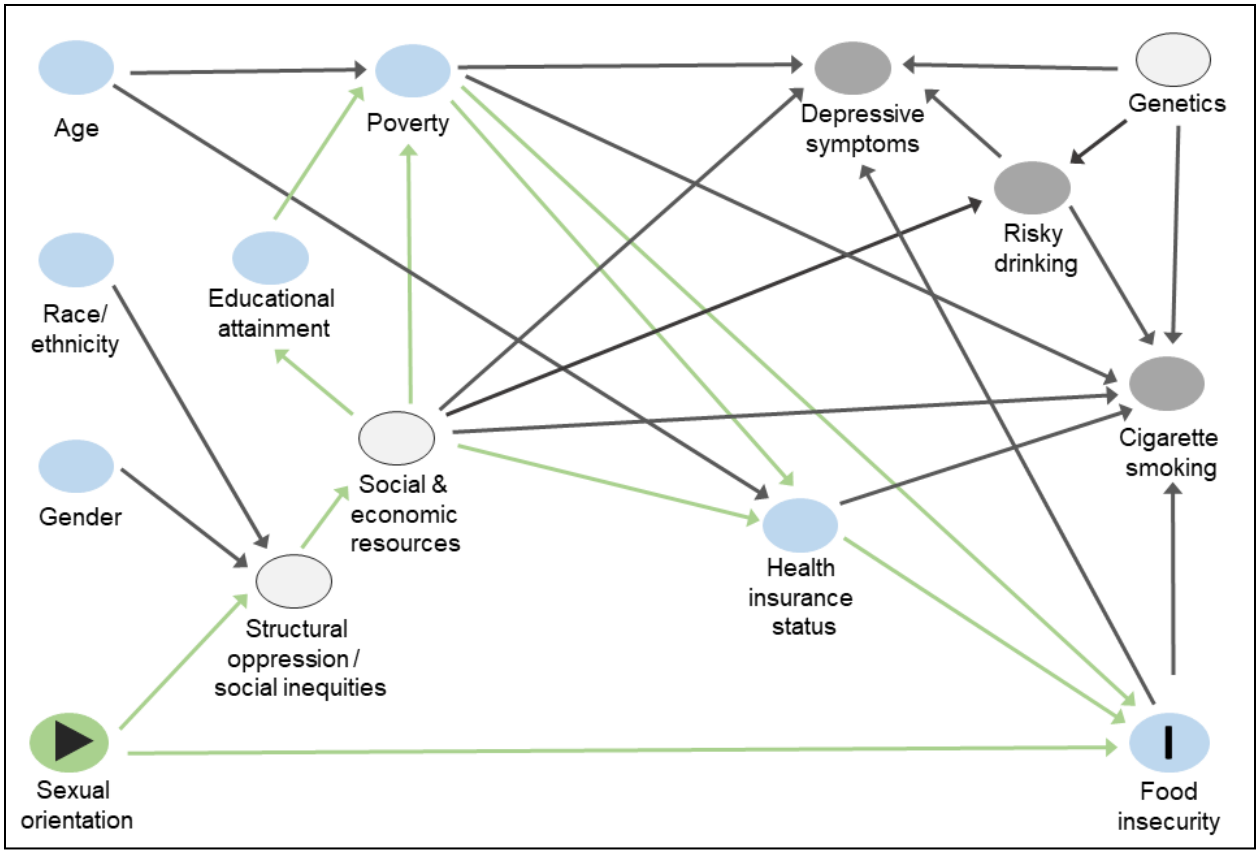

Figure 4.3 Working model depicting hypothesized pathways between sexual orientation and food insecurity

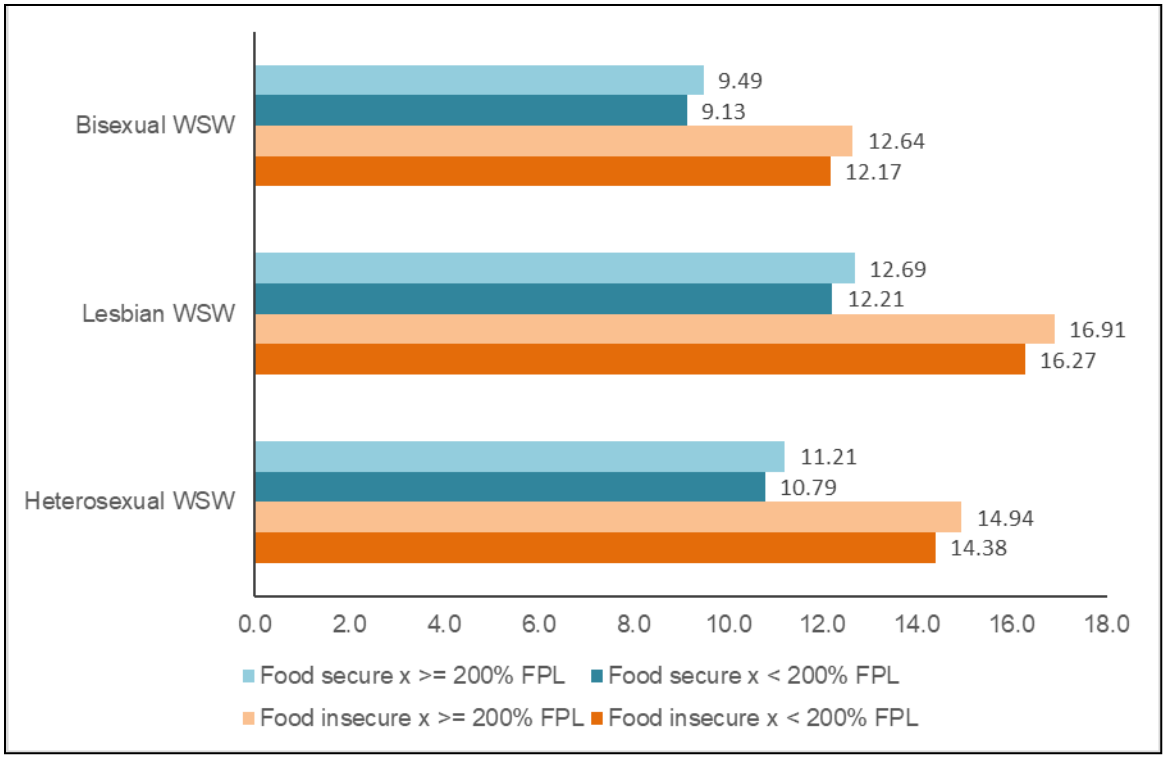

Figure 4.4 Predicted average daily cigarettes in sexual minority women smokers defined in terms of sexual identity and lifetime sexual behavior, by food insecurity and poverty status

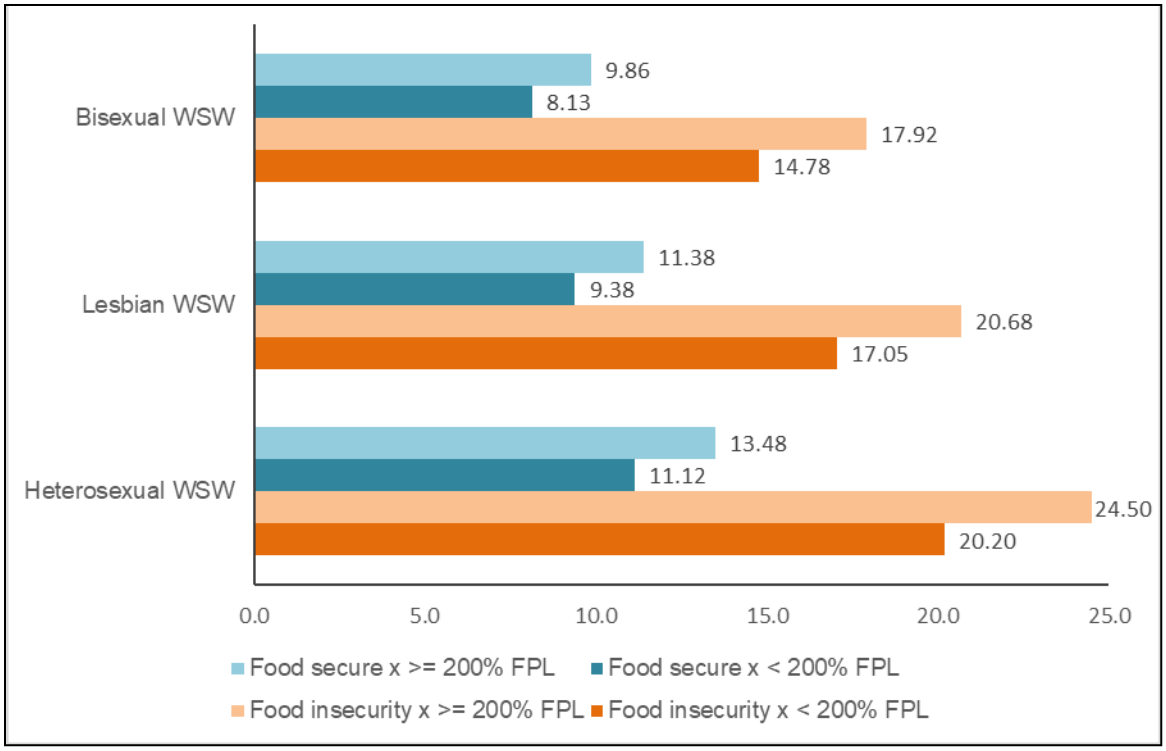

Figure 4.5 Predicted average daily cigarettes in sexual minority women smokers defined in terms of sexual identity and 12-month sexual behavior, by food insecurity and poverty status

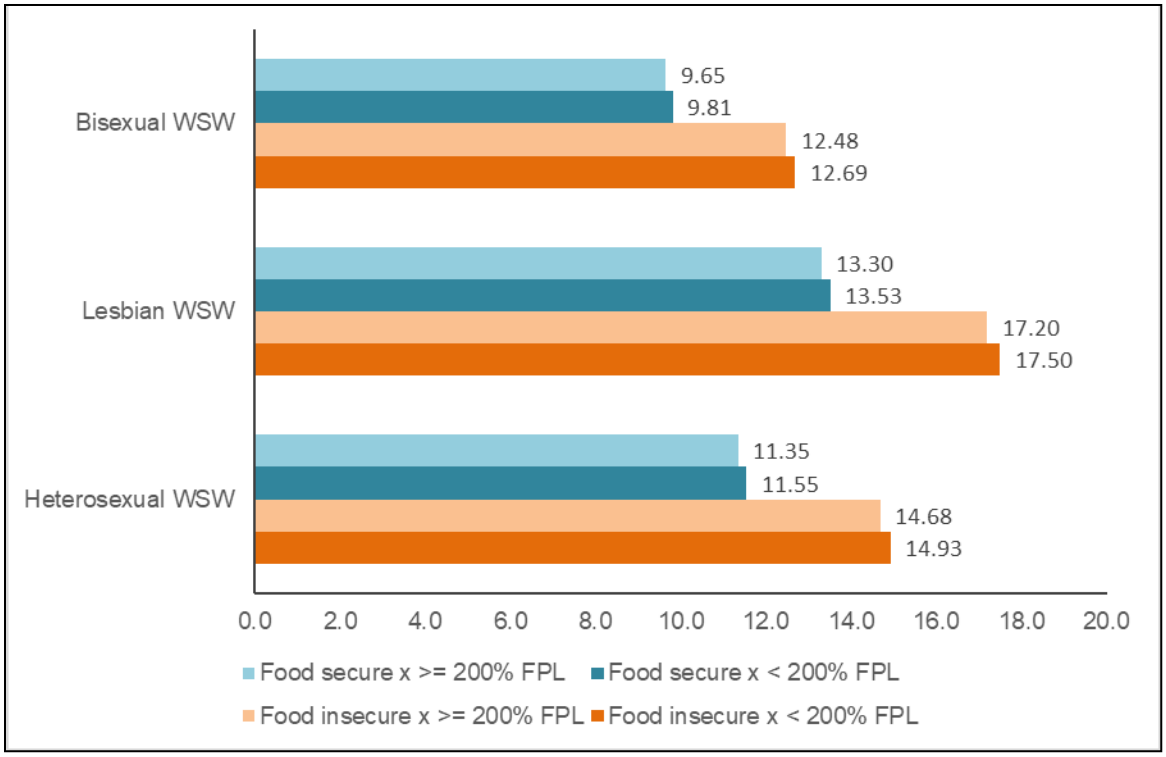

Figure 4.6 Predicted average daily cigarettes in sexual minority women smokers defined in terms of sexual identity and lifetime sexual behavior, by severe food insecurity and poverty status

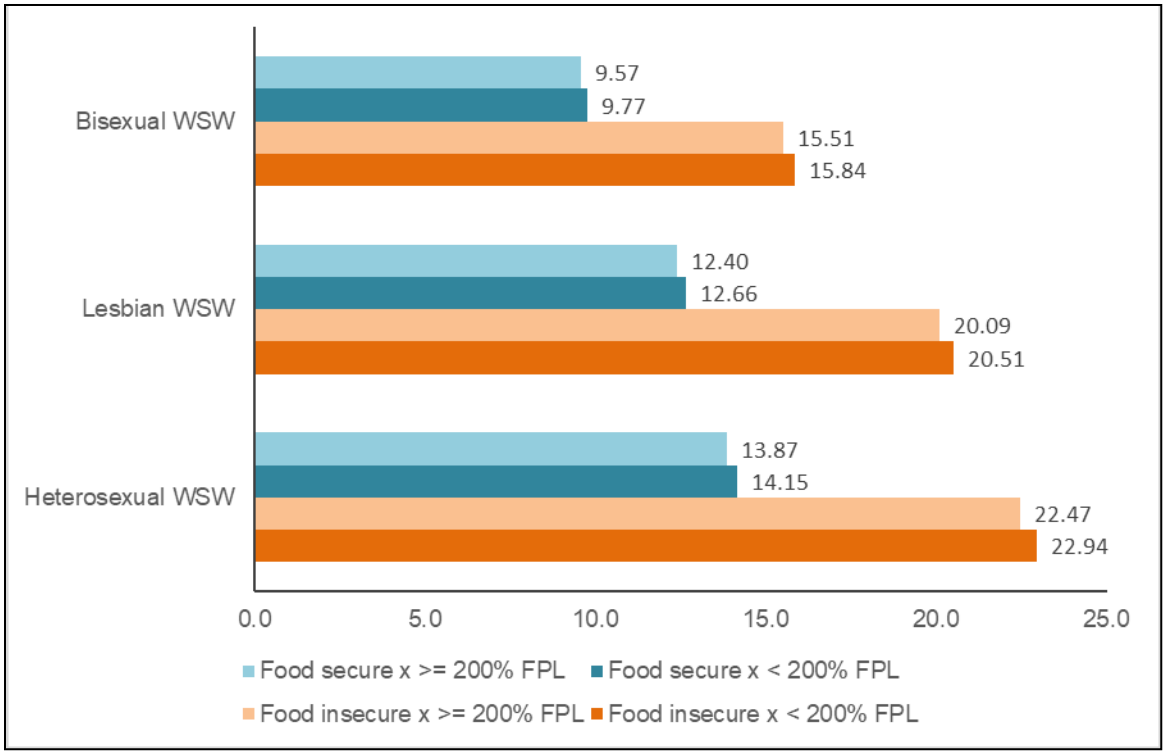

Figure 4.7 Predicted average daily cigarettes in sexual minority women smokers defined in terms of sexual identity and 12-month sexual behavior, by severe food insecurity and poverty status

Table 4.1 Coding key defining sexual minority and heterosexual women and men by sexual identity, and in terms of sexual identity and same-sex sexual behavior (lifetime and 12-month) by study aim

	Aim 1: Full analytic sample Sexual identity			Aim 2: Subset of sexual minorities Sexual identity		
	Heterosexual	Lesbian	Bisexual	Heterosexual	Lesbian	Bisexual
Women						
Sexual identity						
Heterosexual	Heterosexual (coded 0)					
Lesbian		Lesbian (coded 1)			Lesbian (coded 0)	
Bisexual			Bisexual (coded 2)			Bisexual (coded 1)
Lifetime sexual behavior						
Any same-sex behavior	Heterosexual WSW (coded 3)	Lesbian WSW (coded 1)	Bisexual WSW (coded 2)	Heterosexual WSW (coded 0)	Lesbian WSW (coded 1)	Bisexual WSW (coded 2)
Opposite-sex behavior	Heterosexual WSM (coded 0)					
12-month sexual behavior						
Any same-sex behavior	Heterosexual WSW (coded 3)	Lesbian WSW (coded 1)	Bisexual WSW (coded 2)	Heterosexual WSW (coded 0)	Lesbian WSW (coded 1)	Bisexual WSW (coded 2)
Opposite-sex behavior	Heterosexual WSM (coded 0)					

Table 4.1 continued

	Aim 1: Full analytic sample Sexual identity			Aim 2: Subset of sexual minorities Sexual identity		
	Heterosexual	Gay	Bisexual	Heterosexual	Lesbian	Bisexual
Men						
Sexual identity						
Heterosexual	Heterosexual (coded 0)					
Lesbian		Gay (coded 1)			Gay (coded 0)	
Bisexual			Bisexual (coded 2)			Bisexual (coded 1)
Lifetime sexual behavior						
Any same-sex behavior	Heterosexual MSM (coded 3)	Gay MSM (coded 1)	Bisexual MSM (coded 2)	Heterosexual MSM (coded 0)	Gay MSM (coded 1)	Bisexual MSM (coded 2)
Opposite-sex behavior	Heterosexual MSW (coded 0)					
12-month sexual behavior						
Any same-sex behavior	Heterosexual MSM (coded 3)	Gay MSM (coded 1)	Bisexual MSM (coded 2)	Heterosexual MSM (coded 0)	Gay MSM (coded 1)	Bisexual MSM (coded 2)
Opposite-sex behavior	Heterosexual MSW (coded 0)					

WSW = women who have sex with women; WSM = women who exclusively have sex with men; MSM = men who have sex with men; MSW = men who exclusively have sex with women

Table 4.2 Unweighted sample characteristics in sexual minority women and men, by self-reported sexual orientation: National Health and Nutrition Examination Survey, 2005-2014

	Sexual Identity				Sexual Identity + Lifetime Sexual Behavior					Sexual Identity + 12 month Sexual Behavior				
	Lesbian	Bisexual			Heterosexual WSW	Lesbian WSW	Bisexual WSW			Heterosexual WSW	Lesbian WSW	Bisexual WSW		
	n (%)		X2	p	n (%)			X2	p	n (%)			X2	p
Women														
Total	91 (22.9)	306 (77.1)			352 (52.1)	82 (12.1)	242 (35.8)			34 (16.4)	68 (32.9)	105 (50.7)		
Race/Ethnicity			0.5	0.93				4.4	0.63				9.5	0.15
White, non-Hispanic	44 (48.4)	154 (50.3)			194 (55.1)	40 (48.8)	123 (50.8)			11 (32.4)	33 (48.5)	44 (41.9)		
Black, non-Hispanic	27 (29.7)	82 (26.8)			78 (22.2)	25 (30.5)	69 (28.5)			16 (47.1)	22 (32.3)	39 (37.1)		
Hispanic	13 (14.3)	42 (13.7)			54 (15.3)	11 (13.4)	33 (13.6)			2 (5.6)	9 (13.2)	18 (17.1)		
Multiple races	7 (7.7)	28 (9.2)			26 (7.4)	6 (7.3)	17 (17.0)			5 (14.7)	4 (5.9)	4 (3.8)		
Age			22.5	<.001				35.6	<.001				17.1	0.009
18-25	19 (20.9)	115 (37.6)			67 (19.0)	18 (22.0)	83 (34.3)			12 (35.3)	17 (25.0)	45 (42.9)		
26-25	19 (20.9)	97 (31.7)			99 (28.1)	17 (20.7)	82 (33.9)			9 (26.5)	17 (25.0)	37 (35.2)		
36-45	30 (33.0)	51 (16.7)			91 (25.9)	26 (31.7)	41 (16.9)			6 (17.7)	23 (33.8)	14 (13.3)		
46-59	23 (25.2)	43 (14.0)			95 (27.0)	21 (25.6)	36 (14.9)			7 (20.6)	11 (16.2)	9 (8.6)		
Educational Level			5.6	0.06				16.1	0.003				9.9	0.04
≤ High school	34 (37.4)	129 (42.2)			106 (30.1)	27 (32.9)	107 (44.2)			13 (38.2)	24 (35.3)	53 (50.5)		
Some college/AA degree	31 (34.5)	125 (40.9)			157 (44.6)	30 (36.6)	93 (38.4)			15 (44.1)	24 (35.3)	40 (38.1)		
College graduate or above	26 (28.6)	52 (16.7)			89 (25.3)	25 (30.5)	42 (17.4)			6 (17.7)	20 (29.4)	12 (11.4)		

Table 4.2 continued

	Sexual Identity				Sexual Identity + Lifetime Sexual Behavior					Sexual Identity + 12 month Sexual Behavior				
	Lesbian	Bisexual			Heterosexual WSW	Lesbian WSW	Bisexual WSW			Heterosexual WSW	Lesbian WSW	Bisexual WSW		
	n (%)		X2	p	n (%)			X2	p	n (%)			X2	p
Marital Status			29.7	<.001				120.0	<.001				39.7	<.001
Married	4 (4.4)	77 (25.2)			143 (40.6)	-	57 (23.6)			8 (23.5)	-	14 (13.3)		
Widowed	-	3 (1.0)			11 (3.1)	-	3 (1.2)			2 (5.9)	-	2 (1.9)		
Divorced	9 (9.9)	39 (12.8)			61 (17.3)	8 (9.8)	32 (13.2)			4 (11.8)	7 (10.3)	12 (11.4)		
Separated	1 (1.1)	7 (2.3)			14 (4.0)	1 (1.2)	5 (2.1)			3 (8.8)	-	3 (2.9)		
Never married	53 (58.2)	130 (42.5)			84 (23.9)	50 (61.0)	104 (43.0)			15 944.1)	50 (58.8)	56 (53.3)		
Living with partner	24 (26.4)	50 (16.3)			39 (11.1)	23 (28.0)	41 (16.9)			2 (5.9)	21 (30.9)	18 (17.1)		
% Federal Poverty Level			3.2	0.52				10.9	0.21				4.9	0.76
< 100%	23 (23.1)	51 (16.7)			83 (23.6)	19 (23.2)	40 (16.5)			7 (20.6)	16 (23.5)	14 (13.3)		
100-199%	11 (12.1)	28 (9.2)			42 (11.9)	10 (12.2)	21 (8.7)			3 (8.8)	8 (11.8)	9 (8.6)		
200-299%	10 (11.0)	40 (13.1)			53 (15.1)	8 (9.8)	33 (13.6)			5 (14.7)	7 (10.3)	16 (15.2)		
300-399%	25 (27.5)	88 (28.8)			92 (26.1)	23 (28.1)	73 (30.2)			10 (29.4)	18 (26.5)	37 (35.2)		
≥ 400%	24 (26.4)	99 (33.4)			82 (23.3)	22 (26.8)	75 (31.0)			9 (26.5)	19 (27.9)	29 (27.6)		
Insurance Type			16.3	0.003				33.0	<.001				13.6	0.09
Private	36 (40.0)	120 (39.6)			168 (47.7)	33 (40.7)	91 (37.8)			13 (38.2)	28 (41.2)	39 (37.5)		
Medicare/Medigap	5 (5.6)	1 (0.3)			10 (2.8)	5 (6.2)	1 (0.4)			-	2 (2.9)	-		
Medicaid	6 (6.7)	51 (16.8)			64 (18.2)	4 (4.9)	40 (16.6)			5 (14.7)	3 (4.4)	20 (19.2)		
Other public	6 (6.7)	23 (7.6)			20 (5.7)	5 (6.2)	20 (8.3)			3 (8.8)	4 (5.9)	7 (6.7)		
None	37 (41.1)	108 (35.6)			90 (25.6)	34 (42.0)	89 (36.9)			13 (38.2)	31 (45.6)	38 (36.5)		

Table 4.2 continued

	Sexual Identity				Sexual Identity + Lifetime Sexual Behavior					Sexual Identity + 12 month Sexual Behavior				
	Lesbian	Bisexual			Heterosexual WSW	Lesbian WSW	Bisexual WSW			Heterosexual WSW	Lesbian WSW	Bisexual WSW		
	n (%)		X2	p	n (%)			X2	p	n (%)			X2	p
Depressive Symptoms			10.4	0.04				14.1	0.08				6.5	0.59
Minimal	62 (68.1)	152 (49.7)			209 (59.4)	58 (70.7)	124 (51.2)			22 (64.7)	46 (67.7)	52 (49.5)		
Mild	15 (16.5)	79 (25.8)			77 (21.9)	11 (13.4)	56 (23.1)			6 (17.7)	11 (16.2)	27 (25.7)		
Moderate	8 (7.9)	43 (14.1)			41 (11.7)	7 (8.5)	34 (14.1)			3 (8.8)	6 (8.8)	15 (14.3)		
Moderately severe	3 (3.3)	21 (6.9)			19 (5.4)	3 (3.7)	19 (7.9)			2 (5.9)	3 (4.4)	7 (6.7)		
Severe	3 (3.3)	11 (3.6)			6 (1.7)	3 (3.7)	9 (3.7)			1 (2.9)	2 (2.9)	4 (3.8)		
Risky Drinker	56 (61.5)	197 (64.4)	0.2	0.62	210 (59.7)	51 (62.2)	164 (67.8)	4.1	0.13	26 (76.5)	45 (66.2)	73 (69.5)	1.2	0.56
Current Smoker	38 (41.8)	140 (45.8)	0.5	0.50	132 (37.5)	35 (42.7)	123 (50.8)	10.4	0.006	15 (44.1)	30 (44.1)	53 (50.5)	0.8	0.66
Food Insecure	28 (30.8)	102 (33.3)	0.2	0.65	97 (27.6)	25 (30.5)	80 (33.1)	2.1	0.35	9 (26.5)	21 (30.9)	34 (32.4)	0.4	0.81

	Sexual Identity				Sexual Identity + Lifetime Sexual Behavior					Sexual Identity + 12 month Sexual Behavior				
	Gay	Bisexual			Heterosexual MSM	Gay MSM	Bisexual MSM			Heterosexual MSM	Gay MSM	Bisexual MSM		
	n (%)		X2	p	n (%)			X2	p	n (%)			X2	p
<u>Men</u>														
Total	155 (58.5)	110 (41.5)			142 (38.9)	152 (41.6)	71 (19.5)			6 (37.5)	41 (31.3)	18 (43.9)		
Race/Ethnicity			0.9	0.83				7.9	0.25				10.1	0.12
White, non-Hispanic	75 (48.4)	52 (47.3)			68 (47.9)	74 (48.7)	37 (52.1)			7 (43.8)	60 945.8)	18 (43.9)		
Black, non-Hispanic	34 (21.9)	29 (26.4)			25 (17.6)	32 (21.1)	19 (26.8)			3 918.8)	28 (21.4)	15 (36.6)		
Hispanic	32 (20.7)	21 (19.1)			40 (28.2)	21 (21.1)	13 (18.3)			5 931.3)	31 (23.7)	8 (19.5)		
Other	14 (9.0)	8 (7.3)			9 (6.3)	14 (9.2)	2 (2.8)			1 (6.3)	12 (9.2)	-		

Table 4.2 continued

	Sexual Identity				Sexual Identity + Lifetime Sexual Behavior					Sexual Identity + 12 month Sexual Behavior				
	Gay	Bisexual			Heterosexual MSM	Gay MSM	Bisexual MSM			Heterosexual MSM	Gay MSM	Bisexual MSM		
	n (%)		X2	p	n (%)			X2	p	n (%)			X2	p
Age			4.3	0.24				9.5	0.15				6.4	0.38
20-25	30 (19.4)	17 (15.5)			17 (12.0)	29 (19.1)	8 (11.3)			2 (12.5)	28 (21.4)	7 (17.1)		
26-25	46 (29.7)	28 (25.5)			34 (23.9)	46 (30.3)	19 (26.8)			4 (25.0)	44 (33.6)	11 (26.8)		
36-45	37 (23.9)	22 (20.0)			44 (31.0)	36 (23.7)	15 (21.1)			5 (31.3)	34 (26.0)	8 (19.5)		
46-59	42 (27.1)	43 (39.1)			47 (33.1)	41 (27.0)	29 (40.9)			5 (31.3)	25 (19.1)	15 (36.6)		
Educational Level			25.4	<.001				23.3	<.001				16.2	0.003
≤ High school	33 (21.3)	52 (47.3)			54 (38.0)	31 (20.4)	33 (46.5)			6 (37.5)	27 (20.6)	19 (46.3)		
Some college/AA degree	55 (35.5)	37 (33.6)			31 (20.4)	54 (35.5)	22 (31.0)			7 (43.8)	44 (33.6)	14 935.2)		
College graduate or above	67 (43.2)	21 (19.1)			33 (46.5)	67 (44.1)	16 (22.5)			3 (18.8)	60 (45.8)	8 (19.5)		
Marital Status			80.3	<.001				147.5	<.001				49.3	<.001
Married	4 (2.6)	33 (30.0)			62 (43.7)	4 (2.6)	21 (29.6)			5 (31.3)	4 (3.1)	5 912.2)		
Widowed	-	1 (0.9)			-	-	1 (1.4)			-	-	1 (2.4)		
Divorced	3 (1.9)	16 (14.6)			23 (16.2)	3 (2.0)	13 (18.3)			1 (6.3)	2 (1.5)	10 (24.4)		
Separated	2 (1.3)	4 (3.6)			6 (4.2)	2 (1.3)	3 94.2)			1 (6.3)	2 (1.5)	1 (2.4)		
Never married	103 (66.5)	50 (45.5)			30 (21.1)	102 (67.1)	29 (40.9)			5 (31.3)	85 (64.9)	22 (53.7)		
Living with partner	43 (27.7)	6 (5.5)			21 (14.8)	41 (27.0)	4 (5.6)			4 (25.0)	38 (29.0)	2 (4.9)		
% Federal Poverty Level			13.8	0.008				23.5	0.003				36.3	<.001
< 100%	59 (38.1)	25 (22.7)			37 (26.1)	58 (38.2)	18 (25.3)			4 (25.0)	51 (38.9)	7 (17.1)		
100-199%	17 (11.0)	9 (8.2)			14 (9.9)	17 (11.2)	6 (8.5)			-	14 (10.7)	5 (12.2)		
200-299%	29 (18.7)	17 (15.5)			20 (4.1)	29 (19.1)	9 (12.7)			-	27 (20.6)	7 (17.1)		
300-399%	20 (12.9)	29 (26.4)			29 (34.5)	20 (13.2)	22 (31.0)			11 (68.8)	15 (11.5)	11 (26.8)		
≥ 400%	30 (19.4)	30 (27.3)			22 (15.5)	28 (22.5)	16 (22.5)			1 (6.3)	24 (18.3)	11 (26.8)		

Table 4.2 continued

	Sexual Identity				Sexual Identity + Lifetime Sexual Behavior					Sexual Identity + 12 month Sexual Behavior				
	Gay	Bisexual			Heterosexual MSM	Gay MSM	Bisexual MSM			Heterosexual MSM	Gay MSM	Bisexual MSM		
	n (%)		X2	p	n (%)			X2	p	n (%)			X2	p
Insurance			16.8	0.002				15.2	0.06				4.2	0.12
Private	94 (61.4)	44 (40.4)			75 (53.2)	92 (61.3)	31 (44.3)			6 (37.5)	86 (66.2)	17 (42.5)		
Medicare/Medigap	7 (4.6)	2 (1.8)			1 (0.7)	6 (4.0)	2 (2.9)			-	2 (1.5)	1 (2.5)		
Medicaid	9 (5.9)	17 (15.6)			10 (7.1)	9 (6.0)	12 (17.1)			2 (12.5)	6 (4.6)	6 (15.0)		
Other public	9 (5.9)	11 (10.1)			10 (7.1)	9 (6.0)	5 (7.1)			1 (6.3)	6 (4.6)	2 (5.0)		
None	34 (22.2)	35 (32.1)			45 (31.9)	34 (22.7)	20 (28.6)			7 (43.8)	30 (23.1)	14 (35.0)		
Depressive Disorder			9.3	0.06				11.8	0.16				12.7	0.12
Minimal	114 (73.6)	72 (65.5)			91 (64.1)	112 (73.7)	46 (64.8)			8 (50.0)	98 (74.8)	26 (63.4)		
Mild	27 (17.4)	24 (21.8)			34 (23.9)	27 (17.8)	16 (22.5)			4 (25.0)	22 (16.8)	9 (22.0)		
Moderate	11 (7.1)	8 (7.3)			7 (4.9)	10 (6.6)	6 (8.5)			3 (18.8)	8 (6.1)	3 (7.3)		
Moderately severe	1 (0.7)	6 (5.5)			7 (4.9)	1 (0.7)	3 (4.2)			-	1 (0.8)	3 (7.3)		
Severe	2 (1.3)	-			3 (2.1)	2 (1.3)	-			1 (6.3)	2 (1.5)	-		
Risky Drinker	50 (32.3)	43 (39.1)	1.3	0.25	52 (36.6)	49 (32.2)	30 (42.2)	2.2	0.34	5 (31.3)	48 (36.6)	18 (43.9)	1.0	0.60
Current Smoker	49 (31.6)	43 (39.1)	1.6	0.21	45 (31.7)	49 (32.2)	29 (40.9)	2.0	0.37	6 (37.5)	41 (31.3)	18 (43.9)	2.1	0.33
Food Security	37 (23.9)	32 (29.1)	0.9	0.34	35 (24.7)	36 (23.7)	20 (28.2)	0.5	0.77	7 (43.8)	20 (22.9)	13 (31.7)	3.7	0.16

X2 = likelihood ratio chi-squared; p = p-value.

Table 4.3 Weighted bivariate associations between food security and smoking behaviors in sexual minority women and men: National Health and Nutrition Examination Survey, 2005-2014

	Full sample			Among smokers only					
	Current smoker			Nicotine dependence			Smoking intensity		
	% (SE)	X2	p	% (SE)	X2	p	IRR	t	p
Women									
Sexual Identity		13.24	<.001		3.85	0.05		0.92	0.36
Food secure	36.2 (2.7)			48.6 (5.9)			Ref		
Food insecure	57.4 (4.9)			65.5 (7.1)			1.17		
Sexual Identity + Lifetime same-sex behavior		18.48	<.001		3.06	0.08		1.92	0.06
Food secure	35.9 (2.3)			54.0 (4.3)			Ref		
Food insecure	57.6 (4.0)			64.6 (4.3)			1.24		
Sexual Identity + 12 month same-sex behavior		4.55	0.04		1.38	0.25		2.63	0.01
Food secure	40.6 (4.0)			53.1 (7.6)			Ref		
Food insecure	58.4 (7.4)			70.4 (9.9)			1.53		
Men									
Sexual Identity		6.38	0.01		1.43	0.02		2.17	0.03
Food secure	29.6 (4.3)			47.3 (7.9)			Ref		
Food insecure	52.2 (8.2)			63.3 (9.6)			1.38		
Sexual Identity + Lifetime same-sex behavior		19.50	<.001		0.06	0.43		0.99	0.44
Food secure	27.4 (3.5)			52.6 (6.8)			Ref		
Food insecure	53.6 (6.3)			61.5 (8.0)			1.13		
Sexual Identity + 12 month same-sex behavior		3.20	0.08		2.05	0.13		0.37	0.71
Food secure	31.0 (5.1)			49.6 (8.7)			Ref		
Food insecure	49.8 (8.9)			73.6 (11.5)			1.09		

% = weighted percent; SE = standard error; X2 = likelihood ratio chi-squared; p = p-value

Table 4.4 Weighted bivariate associations between food security and smoking behaviors in sexual minority women and men: National Health and Nutrition Examination Survey, 2005-2014

	Full sample			Among smokers only					
	Current smoking			Nicotine dependence			Smoking Intensity		
	Sexual Identity	Sexual Identity + lifetime same-sex behavior	Sexual Identity + past 12-month same-sex behavior	Sexual Identity	Sexual Identity + lifetime same-sex behavior	Sexual Identity + past 12-month same-sex behavior	Sexual Identity	Sexual Identity + lifetime same-sex behavior	Sexual Identity + past 12-month same-sex behavior
	aOR (95% CI)			aOR (95% CI)			IRR (95% CI)		
Women									
Food insecure	1.36 (0.81-2.31)	**1.70 (1.11-2.59)**	1.55 (0.71-3.38)	1.33 (0.60-2.94)	0.94 (0.55-1.62)	2.22 (0.77-6.40)	1.20 (0.85-1.68)	**1.33 (1.07-1.66)**	**1.82 (1.20-2.74)**
Sexual orientation									
Heterosexual WSW	N/A	Ref	Ref	N/A	Ref	Ref	N/A	Ref	Ref
Lesbian / Lesbian WSW	Ref	1.07 (0.63-1.80)	0.64 (0.21-1.95)	Ref	0.40 (0.16-1.06)	0.23 (0.03-1.80)	Ref	1.13 (0.86-1.49)	0.84 (0.61-1.17)
Bisexual / Bisexual WSW	1.16 (0.71-1.88)	1.26 (0.85-1.89)	0.93 (0.26-3.30)	1.78 (0.71-4.48)	0.79 (0.39-1.61)	0.60 (0.11-3.29)	0.77 (0.55-1.08)	0.85 (0.67-1.07)	0.73 (0.51-1.06)
Poverty Level									
≥ 200%	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
< 200% (Poor/Near Poor)	**2.01 (1.13-3.58)**	**1.81 (1.12-2.92)**	1.04 (0.46-2.36)	1.77 (0.70-4.43)	**2.09 (1.02-4.26)**	0.93 (0.29-2.98)	0.99 (0.59-1.67)	0.96 (0.73-1.28)	0.82 (0.52-1.30)
Health Insurance									
Private	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Public	1.66 (0.81-3.41)	1.05 (0.62-1.78)	2.52 (0.74-8.57)	2.89 (0.74-11.34)	1.80 (0.73-4.42)	4.41 (0.71-27.54)	0.87 (0.50-1.54)	0.84 (0.62-1.14)	0.66 (0.36-1.19)
None	**2.17 (1.20-3.91)**	1.43 (0.90-2.26)	1.44 (0.71-2.91)	1.79 (0.60-5.37)	1.35 (0.58-3.12)	3.34 (0.65-17.24)	0.94 (0.59-1.50)	0.96 (0.74-1.26)	0.80 (0.52-1.25)

Table 4.4 continued

	Full sample			Among smokers only					
	Current smoking			Nicotine dependence			Smoking Intensity		
	Sexual Identity	Sexual Identity + lifetime same-sex behavior	Sexual Identity + past 12-month same-sex behavior	Sexual Identity	Sexual Identity + lifetime same-sex behavior	Sexual Identity + past 12-month same-sex behavior	Sexual Identity	Sexual Identity + lifetime same-sex behavior	Sexual Identity + past 12-month same-sex behavior
	aOR (95% CI)			aOR (95% CI)			IRR (95% CI)		
Men									
Food insecure	1.53 (0.59-3.96)	1.84 (0.93-3.64)	1.18 (0.36-3.90)	1.72 (0.44-6.67)	1.42 (0.51-3.98)	2.97 (0.62-14.18)	1.29 (0.92-1.79)	1.11 (0.84-1.46)	1.17 (0.77-1.76)
Sexual orientation									
Heterosexual MSM	N/A	Ref	Ref	N/A	Ref	Ref	N/A	Ref	Ref
Gay / Gay MSM	Ref	1.57 (0.84-2.95)	2.06 (0.62-6.92)	Ref	1.00 (0.28-3.59)	0.26 (0.01-6.04)	Ref	0.67 (0.45-1.00)	**0.38 (0.18-0.81)**
Bisexual / Bisexual MSM	0.80 (0.41-1.57)	1.08 (0.46-2.54)	1.91 (0.50-7.30)	0.59 (0.16-2.10)	0.50 (0.09-2.74)	0.32 (0.01-7.73)	1.21 (0.85-1.73)	0.76 (0.2-1.12)	0.58 (0.30-1.12)
Poverty Level									
≥ 200%	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
< 200% (Poor/Near Poor)	1.84 (0.91-3.74)	**2.06 (1.07-3.96)**	1.61 (0.61-4.28)	3.67 (0.78-17.28)	**4.18 (1.23-14.20)**	1.36 (0.26-7.22)	1.10 (0.79-1.52)	1.07 (0.81-1.42)	0.92 (0.65-1.30)
Health Insurance									
Private	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Public	1.95 (0.78-4.86)	**2.15 (1.04-4.43)**	3.36 (0.96-11.70)	0.49 (0.09-2.87)	0.43 (0.09-1.99)	0.81 (0.09-7.69)	1.39 (0.95-2.04)	1.21 (0.84-1.75)	1.47 (0.92-2.35)
None	2.13 (0.90-5.06)	**2.49 (1.28-4.85)**	**4.04 (1.58-10.37)**	0.71 (0.14-3.76)	0.65 (0.15-2.77)	0.75 (0.13-4.24)	0.68 (0.42-1.08)	0.82 (0.57-1.19)	0.84 (0.56-1.27)

aOR = adjusted odds ratio; CI = confidence interval; FPL = federal poverty level. Multivariable regression analyses adjusted for the DAG-identified covariates minimally sufficient to estimate the direct association between food insecurity and smoking.

Table 4.5 Sensitivity analyses. Weighted bivariate associations between severe food insecurity and smoking behaviors in sexual minority women and men: National Health and Nutrition Examination Survey, 2005-2014

	Full sample			Among smokers only					
	Current smoker			Nicotine dependence			Smoking intensity		
	% (SE)	X2	p	% (SE)	X2	p	IRR	t	p
Women									
Sexual Identity		8.40	0.005		2.50	0.12		0.41	0.68
Food secure	38.7 (138)			51.2 (6.0)			Ref		
Severely food insecure	61.6 (6.6)			70.5 (9.3)			1.07		
Sexual Identity + Lifetime same-sex behavior		13.28	<.001		2.43	0.12		1.87	0.07
Food secure	35.8 (2.0)			55.4 (3.9)			Ref		
Severely food insecure	58.9 (5.1)			67.8 (6.2)			1.26		
Sexual Identity + 12 month same-sex behavior		1.70	0.20		2.41	0.13		2.08	0.04
Food secure	43.6 (4.1)			55.7 (5.7)			Ref		
Severely food insecure	56.3 (8.2)			78.8 (12.0)			1.51		
Men									
Sexual Identity		7.34	0.008		0.56	0.46		0.87	0.39
Food secure	30.5 (4.0)			50.3 (7.0)			Ref		
Severely food insecure	66.2 (11.9)			61.5 (12.4)			1.22		
Sexual Identity + Lifetime same-sex behavior		14.17	<.001		1.60	0.20		0.84	0.41
Food secure	28.8 (3.5)			51.4 (6.1)			Ref		
Severely food insecure	63.8 (9.0)			69.0 (10.5)			1.16		
Sexual Identity + 12 month same-sex behavior		7.70	0.007		3.28	0.08		-0.13	0.90
Food secure	31.1 (4.6)			50.2 (7.9)			Ref		
Severely food insecure	71.5 (11.9)			81.4 (12.5)			0.97		

% = weighted percent; SE = standard error; X2 = likelihood ratio chi-squared; p = p-value

Table 4.6 Severe food insecurity as a predictor of self-reported smoking, nicotine dependence, and smoking intensity in sexual minority women and men using DAG-identified covariates: National Health and Nutrition Examination Survey, 2005-2014

	Full sample			Among smokers only					
	Current smoking			Nicotine dependence			Smoking Intensity		
	Sexual Identity	Sexual Identity + lifetime same-sex behavior	Sexual Identity + past 12-month same-sex behavior	Sexual Identity	Sexual Identity + lifetime same-sex behavior	Sexual Identity + past 12-month same-sex behavior	Sexual Identity	Sexual Identity + lifetime same-sex behavior	Sexual Identity + past 12-month same-sex behavior
	aOR (95% CI)			aOR (95% CI)			IRR (95% CI)		
Women									
Severely food insecure	1.43 (0.67-3.05)	1.51 (0.92-2.47)	1.40 (0.58-3.39)	1.46 (0.49-4.33)	1.14 (0.55-2.36)	2.79 (0.63-12.28)	1.10 (0.78-1.54)	**1.29 (1.01-1.66)**	**1.62 (1.05-2.51)**
Sexual orientation									
Heterosexual WSW	N/A	Ref	Ref	N/A	Ref	Ref	N/A	Ref	Ref
Lesbian / Lesbian WSW	Ref	1.09 (0.64-1.86)	0.66 (0.22-1.99)	Ref	0.40 (0.15-1.05)	0.35 (0.03-1.94)	Ref	1.17 (0.85-1.62)	0.89 (0.60-1.33)
Bisexual / Bisexual WSW	1.15 (0.70-1.90)	1.29 (0.85-1.94)	0.94 (0.26-3.37)	1.75 (0.71-4.27)	0.80 (0.39-1.62)	0.61 (0.12-3.25)	0.75 (0.52-1.08)	0.85 (0.68-1.07)	0.69 (0.47-1.01)
Poverty Level									
≥ 200%	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
< 200% (Poor/Near Poor)	**2.06 (1.17-3.61)**	**1.97 (1.20-3.24)**	1.12 (0.50-2.49)	1.86 (0.76-4.60)	1.96 (0.93-4.13)	1.06 (0.35-3.17)	1.07 (0.65-1.77)	1.02 (0.76-1.36)	1.02 (0.62-1.68)
Health Insurance									
Private	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Public	1.70 (0.82-3.52)	1.09 (0.64-1.86)	2.79 (0.84-9.27)	2.85 (0.72-11.21)	1.79 (0.74-4.37)	4.68 (0.74-29.68)	0.86 (0.49-1.51)	0.88 (0.63-1.23)	0.63 (0.32-1.24)
None	**2.19 (1.21-3.97)**	1.42 (0.89-2.25)	1.49 (0.75-2.96)	1.75 (0.59-5.24)	1.33 (0.58-3.10)	3.26 (0.63-16.86)	0.93 (0.58-1.50)	0.95 (0.73-1.25)	0.75 (0.46-1.24)

Table 4.6 continued

	Full sample			Among smokers only					
	Current smoking			Nicotine dependence			Smoking Intensity		
	Sexual Identity	Sexual Identity + lifetime same-sex behavior	Sexual Identity + past 12-month same-sex behavior	Sexual Identity	Sexual Identity + lifetime same-sex behavior	Sexual Identity + past 12-month same-sex behavior	Sexual Identity	Sexual Identity + lifetime same-sex behavior	Sexual Identity + past 12-month same-sex behavior
	aOR (95% CI)			aOR (95% CI)			IRR (95% CI)		
Men									
Severely food insecure	2.84 (0.73-11.03)	**2.72 (1.01-7.29)**	3.82 (0.65-22.39)	1.48 (0.35-6.25)	2.56 (0.77-8.57)	4.67 (0.79-27.49)	1.13 (0.81-1.56)	1.17 (0.83-1.64)	1.05 (0.72-1.53)
Sexual orientation									
Heterosexual MSM	N/A	Ref	Ref	N/A	Ref	Ref	N/A	Ref	Ref
Gay / Gay MSM	Ref	1.56 (0.84-2.90)	2.03 (0.55-7.54)	Ref	0.94 (0.27-3.21)	0.26 (0.01-5.64)	Ref	**0.67 (0.45-0.99)**	**0.40 (0.19-0.85)**
Bisexual / Bisexual MSM	0.86 (0.46-1.63)	1.16 (0.51-2.62)	2.21 (0.52-9.37)	0.57 (0.16-2.05)	0.49 (0.09-2.68)	0.33 (0.01-7.78)	1.18 (0.84-1.66)	0.76 (0.51-1.12)	0.59 (0.30-1.13)
Poverty Level									
≥ 200%	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
< 200% (Poor/Near Poor)	1.83 (0.91-3.69)	**2.11 (1.11-4.01)**	1.40 (0.54-3.63)	3.93 (0.87-17.69)	**4.49 (1.21-16.62)**	1.37 (0.26-7.11)	1.15 (0.86-1.52)	1.08 (0.82-1.43)	0.96 (0.70-1.31)
Health Insurance									
Private	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Public	1.83 (0.76-4.43)	**2.14 (1.06-4.33)**	**3.40 (1.01-11.43)**	0.53 (0.10-2.92)	0.36 (0.07-1.79)	0.79 (0.09-7.21)	**1.49 (1.04-2.11)**	1.19 (0.80-1.78)	1.49 (0.94-2.35)
None	1.98 (0.84-4.66)	**2.45 (1.26-4.75)**	**3.50 (1.34-9.15)**	0.77 (0.15-3.89)	0.55 (0.14-2.20)	0.74 (0.14-3.93)	0.71 (0.46-1.09)	0.81 (0.54-1.20)	0.85 (0.58-1.27)

aOR = adjusted odds ratio; CI = confidence interval. Multivariable regression analyses adjusted for the DAG-identified covariates minimally sufficient to estimate the direct association between severe food insecurity and smoking.

Table 4.7 Predicted number of daily cigarettes for sexual minority women, by sexual orientation, food security, and poverty status

	Sexual identity + lifetime same-sex behavior			Sexual identity + past 12-month same-sex behavior		
	Heterosexual WSW	Lesbian WSW	Bisexual WSW	Heterosexual WSW	Lesbian WSW	Bisexual WSW
	Margin (95% CI)			Margin (95% CI)		
Food insecure x < 200% FPL	14.38 (11.62-17.13)	16.27 (10.48-22.06)	12.17 (9.27-15.07)	20.20 (11.09-29.30)	17.05 (9.30-24.81)	14.78 (9.57-19.97)
Food insecure x ≥ 200% FPL	14.94 (10.92-18.96)	16.91 (10.11-23.71)	12.64 (9.17-16.12)	24.50 (11.53-37.47)	20.68 (9.30-32.06)	17.92 (8.16-27.69)
Food secure x < 200% FPL	10.79 (8.29-13.27)	12.21 (8.17-16.24)	9.13 (6.60-11.65)	11.12 (5.90-16.33)	9.38 (4.90-13.86)	8.13 (5.16-11.11)
Food secure ≥ 200% FPL	11.21 (8.03-13.49)	12.69 (8.74-16.63)	9.49 (7.42-11.55)	13.48 (9.89-17.08)	11.38 (7.82-14.94)	9.86 (7.06-12.67)
Sensitivity analyses						
Severely food insecure x < 200% FPL	14.93 (12.08-17.79)	17.50 (10.99-24.00)	12.69 (9.30-16.09)	22.94 (11.23-34.65)	20.51 (10.01-31.01)	15.84 (10.60-21.07)
Severely food insecure x ≥ 200% FPL	14.68 (10.70-18.66)	17.20 (11.10-23.30)	12.48 (7.30-12.32)	22.47 (9.84-35.10)	20.09 (9.83-30.36)	15.51 (7.23-23.79)
Food secure x < 200% FPL	11.55 (8.82-14.27)	13.53 (7.72-19.34)	9.81 (7.30-12.32)	14.15 (6.70-21.61)	12.66 (4.79-20.52)	9.77 (5.76-13.78)
Food secure ≥ 200% FPL	11.35 (9.04-13.67)	13.30 (8.67-17.93)	9.65 (7.58-11.72)	13.87 (10.02-17.72)	12.40 (7.93-16.86)	9.57 (6.73-12.42)

CI = confidence interval; FPL = federal poverty level

Table 4.8 Unweighted sample characteristics in women and men, by self-reported sexual orientation: National Health and Nutrition Examination Survey, 2005-2014

	Sexual Identity					Sexual Identity + Lifetime Sexual Behavior					Sexual Identity + 12 month Sexual Behavior				
	Heterosexual	Lesbian	Bisexual			Heterosexual WSM	Lesbian WSW	Bisexual WSW	Heterosexual WSW		Heterosexual WSM	Lesbian WSW	Bisexual WSW	Heterosexual WSW		
	n (%)			X2	p	n (%)				X2	p	n (%)				X2	p
Women																	
Total	6991 (94.6)	91 (1.2)	306 (4.1)			6339 (90.4)	82 (1.2)	242 (3.5)	352 (5.0)			5735 (96.5)	68 (1.1)	105 (1.8)	34 (0.6)		
Race/Ethnicity				33.4	<.001					56.9	<.001					47.36	<.001
White, non-Hispanic	3109 (44.5)	44 (48.3)	154 (50.3)			2814 (44.4)	40 (48.8)	123 (50.8)	194 (55.1)			2585 (45.1)	33 (48.5)	44 (41.9)	11 (32.4)		
Black, non-Hispanic	1490 (21.3)	27 (29.7)	82 (26.8)			1343 (21.2)	25 (30.5)	69 (28.5)	78 (22.2)			1160 (20.2)	22 (32.4)	39 (37.1)	16 (47.1)		
Hispanic	1788 (25.6)	12 (14.3)	42 (13.7)			1644 (25.9)	11 (13.4)	33 (13.6)	54 (15.3)			1501 (26.2)	9 (13.2)	18 (17.1)	2 (5.9)		
Multiple races	604 (8.6)	7 (7.7)	28 (9.2)			538 (8.5)	6 (7.3)	17 (7.0)	26 (7.4)			489 (8.5)	4 (5.9)	4 (3.8)	5 (14.7)		
Age				124.1	<.001					99.2	<.001						
18-25	1100 (15.7)	19 (20.9)	115 (37.6)			940 (14.8)	18 (22.0)	83 (34.3)	67 (19.0)			945 (16.5)	17 (25.0)	45 (42.9)	12 (35.3)	72.99	<.001
26-35	1762 (25.2)	19 (20.9)	97 (31.7)			1606 (25.3)	17 (20.7)	82 (33.9)	99 (28.1)			1628 (28.4)	17 (25.0)	37 (35.2)	9 (26.5)		
36-45	1842 (26.4)	30 (33.0)	51 (16.7)			1696 (26.8)	26 (31.7)	41 (16.9)	91 (25.9)			1607 (28.0)	23 (33.8)	14 (13.3)	6 (7.6)		
46-59	2287 (32.7)	23 (25.3)	43 (14.0)			2097 (33.1)	21 (25.6)	36 (14.9)	95 (27.0)			1555 (27.1)	11 (16.2)	9 (8.6)	7 (20.6)		

Table 4.8 continued

	Sexual Identity					Sexual Identity + Lifetime Sexual Behavior						Sexual Identity + 12 month Sexual Behavior					
	Heterosexual	Lesbian	Bisexual			Heterosexual WSM	Lesbian WSW	Bisexual WSW	Heterosexual WSW			Heterosexual WSM	Lesbian WSW	Bisexual WSW	Heterosexual WSW		
	n (%)			X2	p	n (%)				X2	p	n (%)				X2	p
Educational Level				15.3	0.004					29.4	<.001					17.39	0.008
≤ High school	2719 (38.9)	34 (37.4)	129 (42.2)			2471 (39.0)	27 (32.9)	107 (44.2)	106 (30.1)			2237 (39.0)	24 (35.3)	53 (50.5)	13 (38.2)		
Some college/AA degree	2428 (34.7)	31 (34.1)	125 (40.8)			2178 (34.4)	20 (36.6)	93 (38.4)	157 (44.6)			1975 (34.4)	24 (35.3)	40 (38.1)	15 (44.1)		
College graduate or above	1844 (26.4)	26 (28.6)	52 (17.0)			1690 (26.7)	25 (30.5)	42 (17.4)	89 (25.3)			1523 (26.6)	20 (29.4)	12 (11.4)	6 (17.7)		
Marital Status				234.2	<.001					280.9	<.001					257.66	<.001
Married	3570 (51.1)	4 (4.4)	77 (25.2)			3353 (52.9)	-	57 (23.6)	143 (40.6)			3301 (57.6)	-	14 (13.3)	8 (23.5)		
Widowed	137 (2.0)	-	3 (1.0)			119 (1.9)	-	3 (1.2)	11 (3.1)			61 (1.1)	-	2 (1.9)	2 (5.9)		
Divorced	825 (11.8)	9 (9.9)	39 (12.8)			740 (11.7)	8 (9.8)	32 (13.2)	61 (17.3)			498 (8.7)	7 (10.3)	12 (11.4)	4 (11.8)		
Separated	299 (4.3)	1 (1.1)	7 (2.3)			277 (4.4)	1 (1.2)	5 (2.1)	14 (4.0)			206 (3.6)	-	3 (2.9)	3 (8.8)		
Never married	1509 (21.6)	53 (58.2)	130 (42.5)			1263 (19.9)	50 (61.0)	104 (43.0)	84 (23.9)			1070 (18.7)	40 (58.8)	56 (53.3)	15 (44.1)		
Living with partner	648 (9.3)	24 (26.4)	50 (16.3)			584 (9.2)	23 (28.0)	41 (16.9)	39 (11.1)			598 (10.4)	21 (30.9)	18 (17.1)	2 (5.9)		

Table 4.8 continued

	Sexual Identity					Sexual Identity + Lifetime Sexual Behavior					Sexual Identity + 12 month Sexual Behavior					
	Heterosexual	Lesbian	Bisexual			Heterosexual WSM	Lesbian WSW	Bisexual WSW	Heterosexual WSW		Heterosexual WSM	Lesbian WSW	Bisexual WSW	Heterosexual WSW		
	n (%)			X2	p	n (%)				X2	p	n (%)				X2	p
% Federal Poverty Level				31.8	<.001					33.7	0.001					23.45	0.02
< 100%	1919 (27.5)	23 (23.1)	51 (16.7)			1779 (28.1)	19 (23.2)	40 (16.5)	83 (23.6)			1643 (28.7)	16 (23.5)	14 (13.3)	7 (20.6)		
100-199%	868 (12.4)	11 (12.1)	28 (9.2)			804 (12.7)	10 (12.2)	21 (8.7)	42 (11.9)			735 (12.8)	8 (11.8)	9 (8.6)	3 (8.8)		
200-299%	923 (13.2)	10 (11.0)	40 (13.1)			838 (13.2)	8 (9.8)	33 (13.6)	53 (15.1)			750 (13.1)	7 (10.3)	16 (15.2)	5 (14.7)		
300-399%	1689 (24.2)	25 (27.5)	88 (28.8)			1498 (23.6)	23 (28.1)	73 (30.2)	92 (26.1)			1349 (23.5)	18 (26.5)	37 (35.2)	10 (29.4)		
≥ 400%	1592 (22.8)	24 (26.4)	99 (33.4)			1420 (22.4)	22 (26.8)	75 (31.0)	82 (23.3)			1258 (21.9)	19 (27.9)	29 (27.6)	9 (26.5)		
Insurance Type				61.4	<.001					85.5	<.001					47.66	<.001
Private	3879 (55.7)	36 (40.0)	120 (39.6)			3568 (56.5)	33 (40.7)	91 (37.8)	168 (47.7)			3284 (57.4)	28 (41.2)	39 (37.5)	13 (38.2)		
Medicare/Medigap	119 (1.7)	5 (5.6)	1 (0.3)			105 (1.7)	5 (6.2)	1 (0.4)	10 (2.8)			68 (1.2)	2 (2.9)	-	-		
Medicaid	774 (11.1)	6 (6.7)	51 (16.8)			665 (10.5)	4 (4.9)	40 (16.6)	64 (18.2)			601 (10.5)	3 (4.4)	20 (19.2)	5 (14.7)		
Other public	533 (7.6)	6 (6.7)	23 (7.6)			487 (7.7)	5 (6.2)	20 (8.3)	20 (5.7)			424 (7.4)	4 (5.9)	7 (6.7)	3 (8.8)		
None	1664 (23.9)	37 (41.1)	108 (35.6)			1492 (23.6)	34 (42.0)	89 (36.9)	90 (25.6)			1340 (23.4)	31 (45.6)	38 (36.5)	13 (38.2)		

Table 4.8 continued

	Sexual Identity					Sexual Identity + Lifetime Sexual Behavior						Sexual Identity + 12 month Sexual Behavior					
	Heterosexual	Lesbian	Bisexual			Heterosexual WSM	Lesbian WSW	Bisexual WSW	Heterosexual WSW			Heterosexual WSM	Lesbian WSW	Bisexual WSW	Heterosexual WSW		
	n (%)			X2	p	n (%)				X2	p	n (%)				X2	p
Depressive Disorder				66.5	<.001					77.6	<.001					31.35	0.002
Minimal	4968 (71.1)	62 (68.1)	152 (49.7)			4534 (71.5)	58 (70.7)	124 (51.2)	209 (59.4)			4155 (72.5)	46 (67.7)	52 (49.5)	22 (64.7)		
Mild	1221 (17.5)	15 (16.5)	79 (25.8)			1104 (17.4)	11 (13.4)	56 (23.1)	77 (21.9)			977 (17.0)	11 (16.2)	27 (25.7)	76 (17.7)		
Moderate	484 (6.9)	8 (8.8)	43 (14.0)			425 (6.7)	7 (8.5)	34 (14.1)	41 (11.6)			377 (6.6)	6 (8.8)	15 (14.3)	3 (8.8)		
Moderately severe	229 (3.3)	3 (3.3)	21 (6.9)			198 (3.1)	3 (3.7)	19 (7.9)	19 (5.4)			161 (2.8)	3 (4.4)	7 (6.7)	2 (5.9)		
Severe	89 (1.3)	3 (3.3)	11 (3.6)			78 (1.2)	3 (3.7)	9 (3.7)	6 (1.7)			65 (1.1)	2 (2.9)	4 (3.8)	1 (2.9)		
Risky Drinker	3055 (43.7)	56 (61.5)	197 (64.4)	61.1	<.001	2764 (43.6)	51 (62.2)	164 (67.8)	210 (59.7)	95.5	<.001	2665 (46.5)	45 (66.2)	73 (69.5)	26 (76.5)	44.67	<.001
Current Smoker	1471 (21.0)	38 (41.8)	140 (45.8)	105.5	<.001	1289 (20.3)	35 (42.7)	123 (50.8)	132 (37.5)	166.3	<.001	1202 (21.0)	30 (44.1)	53 (50.5)	15 (44.1)	69.01	<.001

Table 4.8 continued

	Sexual Identity					Sexual Identity + Lifetime Sexual Behavior						Sexual Identity + 12 month Sexual Behavior					
	Heterosexual	Gay	Bisexual			Heterosexual MSW	Gay MSM	Bisexual MSM	Heterosexual MSM			Heterosexual MSW	Gay MSM	Bisexual MSM	Heterosexual MSM		
	n (%)			X2	p	n (%)				X2	p	n (%)				X2	p
Men																	
Total	6907 (96.3)	155 (2.2)	110 (1.5)			6145 (94.4)	152 (2.3)	71 (1.1)	142 (2.2)			4422 (95.9)	131 (2.8)	41 (0.9)	16 (0.4)		
Race/Ethnicity				5.6	0.47					10.4	0.32					13.63	0.14
White, non-Hispanic	3126 (45.3)	75 (48.4)	52 (47.3)			2888 (47.0)	74 (48.8)	37 (52.1)	68 (47.9)			2038 (46.1)	60 (40.8)	18 (43.9)	7 (43.7)		
Black, non-Hispanic	1413 (20.5)	34 (21.9)	29 (26.4)			1250 (20.3)	32 (21.0)	19 (26.8)	25 (17.6)			938 (21.2)	28 (21.4)	15 (36.6)	3 (18.7)		
Hispanic	1726 (25.0)	32 (20.7)	21 (19.1)			1445 (23.5)	32 (21.0)	13 (18.3)	40 (28.2)			983 (22.2)	31 (23.6)	8 (19.5)	5 (31.3)		
Other	642 (9.2)	14 (9.0)	8 (7.3)			562 (9.2)	14 (9.2)	2 (2.8)	9 (6.3)			463 (10.5)	12 (9.2)	-	1 (6.3)		
Age				6.6	0.36					10.3	0.33					11.81	0.22
20-25	1128 (16.3)	30 (19.3)	17 (15.5)			2034 (33.1)	41 (27.0)	29 (40.8)	47 (33.1)			723 (16.3)	28 (21.4)	7 (17.1)	2 (12.4)		
26-25	1730 (25.0)	46 (29.7)	28 (25.5)			1588 (25.8)	36 (23.7)	15 (21.1)	44 (31.0)			1180 (26.7)	44 (33.6)	11 (26.8)	4 (25.0)		
36-45	1765 (25.6)	37 (23.9)	22 (20.0)			1553 (25.3)	46 (30.3)	19 (26.8)	34 (23.9)			1175 (26.6)	34 (26.0)	8 (19.5)	5 (31.3)		
46-59	2284 (33.1)	42 (27.1)	43 (39.0)			970 (15.8)	29 (19.0)	8 (11.3)	17 (12.0)			1344 (20.4)	25 (19.0)	15 (36.6)	5 (31.3)		

Table 4.8 continued

	Sexual Identity					Sexual Identity + Lifetime Sexual Behavior					Sexual Identity + 12 month Sexual Behavior				
	Heterosexual	Gay	Bisexual			Heterosexual MSW	Gay MSM	Bisexual MSM	Heterosexual MSM		Heterosexual MSW	Gay MSM	Bisexual MSM	Heterosexual MSM	
	n (%)			X2	p	n (%)				X2	p	n (%)				X2	p
Educational Level				52.2	<.001					51.7	<.001					39.57	<.001
≤ High school	3274 (47.4)	33 (21.3)	52 (47.3)			2825 (46.0)	31 (20.4)	33 (46.5)	54 (38.0)			1944 (44.0)	27 (20.6)	19 (46.3)	6 (37.5)		
Some college/AA degree	2053 (29.7)	55 (35.5)	37 (33.6)			1852 (30.1)	54 (35.5)	22 (31.0)	51 (35.9)			1372 (31.0)	44 (33.6)	14 (34.2)	7 (43.8)		
College graduate or above	1580 (28.9)	67 (43.2)	21 (19.1)			1468 (23.9)	67 (44.1)	16 (22.5)	37 (26.1)			1106 (25.0)	60 (45.8)	8 (19.5)	3 (18.7)		
Marital Status				280.5	<.001					289.7	<.001					267.97	<.001
Married	3644 (52.8)	4 (2.6)	33 (30.0)			3315 (54.0)	4 (2.6)	21 (29.6)	62 (43.7)			2489 (56.3)	4 (3.0)	5 (12.2)	5 (31.3)		
Widowed	41 (0.6)	-	1 (0.9)			38 (0.6)	-	1 (1.4)	-			13 (0.3)	-	1 (2.4)	-		
Divorced	583 (8.5)	3 (1.9)	16 (14.6)			518 (8.4)	3 (2.0)	13 (13.8)	23 (16.2)			314 (7.1)	2 (1.5)	10 (24.4)	1 (6.3)		
Separated	207 (3.0)	2 (1.3)	4 (3.6)			186 (3.0)	2 (1.3)	3 (4.2)	6 94.2)			122 (2.8)	2 (1.5)	1 (2.4)	1 (6.3)		
Never married	1677 (24.3)	103 (66.5)	40 (45.5)			1410 (23.0)	102 (67.1)	29 (40.9)	30 (21.1)			964 (21.8)	85 (64.9)	22 (53.7)	5 (31.1)		
Living with partner	751 (10.9)	43 (27.7)	6 (5.4)			673 (11.0)	41 (27.0)	4 (5.6)	21 (14.8)			517 (11.7)	38 (29.0)	2 (4.9)	4 (25.0)		

Table 4.8 continued

	Sexual Identity					Sexual Identity + Lifetime Sexual Behavior					Sexual Identity + 12 month Sexual Behavior					
	Heterosexual	Gay	Bisexual			Heterosexual MSW	Gay MSM	Bisexual MSM	Heterosexual MSM		Heterosexual MSW	Gay MSM	Bisexual MSM	Heterosexual MSM		
	n (%)			X2	p	n (%)				X2	p	n (%)				X2	p
% Federal Poverty Level				22.2	0.005					28.2	0.006					40.04	<.001
< 100%	1952 (28.3)	59 (38.1)	25 (22.7)			1817 (29.6)	58 (38.2)	18 (25.3)	37 (26.1)			1370 (31.0)	51 (38.9)	7 (17.1)	4 (25.0)		
100-199%	837 (12.1)	17 (11.0)	9 (8.2)			763 (12.4)	17 (11.2)	6 (8.5)	14 (9.9)			554 (12.5)	14 (10.7)	5 (12.2)	-		
200-299%	963 (13.9)	29 (18.7)	17 (15.5)			838 (13.6)	29 (19.1)	9 (12.7)	20 (4.1)			612 (13.8)	27 (20.6)	7 (17.1)	-		
300-399%	1684 (24.4)	20 (12.9)	29 (26.4)			1451 (23.6)	20 (13.2)	22 (31.0)	29 (34.5)			1005 (22.7)	15 (11.5)	11 (26.8)	11 (68.8)		
≥ 400%	1471 (21.3)	30 (19.4)	30 (27.3)			1276 (20.8)	28 (22.5)	16 (22.5)	22 (15.5)			881 (19.9)	24 (18.3)	11 (26.8)	1 (6.3)		
Insurance				35.7	<.001					28.8	0.004					16.65	0.16
Private	3668 (53.3)	94 (61.4)	44 (40.4)			3342 (54.6)	92 (61.3)	31 (44.3)	75 (53.2)			2476 (56.2)	86 (66.2)	17 (42.5)	6 (37.5)		
Medicare/Medigap	102 (1.5)	7 (4.6)	2 (1.8)			89 (1.5)	6 (4.0)	2 (2.9)	1 (0.7)			67 (1.5)	2 (1.5)	1 (2.5)	-		
Medicaid	356 (5.2)	9 (5.9)	17 (15.6)			298 (4.9)	9 (6.0)	12 (17.1)	10 (7.1)			212 (4.8)	6 (4.6)	6 (15.0)	2 (12.5)		
Other public	416 (6.0)	9 (5.9)	11 (10.1)			369 (6.0)	9 (6.0)	5 (7.1)	10 (7.1)			242 (5.5)	6 (4.6)	2 (5.0)	1 (6.3)		
None	2338 (34.0)	34 (22.2)	35 (32.1)			2025 (33.1)	34 (22.7)	20 (28.6)	45 (31.9)			1407 (32.0)	20 (23.1)	14 (35.0)	7 (43.7)		

Table 4.8 continued

	Sexual Identity					Sexual Identity + Lifetime Sexual Behavior						Sexual Identity + 12 month Sexual Behavior					
	Heterosexual	Gay	Bisexual			Heterosexual MSW	Gay MSM	Bisexual MSM	Heterosexual MSM			Heterosexual MSW	Gay MSM	Bisexual MSM	Heterosexual MSM		
	n (%)			X2	p	n (%)				X2	p	n (%)				X2	p
Depressive Symptoms				24.0	0.002					41.1	<.001					29.53	0.003
Minimal	5528 (80.0)	114 (73.6)	72 (65.5)			4943 (80.4)	112 (73.7)	46 (64.8)	91 (64.1)			3621 (81.9)	98 (74.8)	26 (63.4)	8 (50.0)		
Mild	938 (13.6)	27 (17.4)	24 (21.8)			819 (13.3)	27 (17.8)	16 (22.5)	34 (23.9)			564 (12.8)	22 (16.8)	9 (22.0)	4 (25.0)		
Moderate	282 (4.1)	11 (7.1)	8 (7.3)			247 (4.0)	10 (6.6)	6 (8.5)	7 (4.9)			154 (3.5)	8 (6.1)	3 97.3)	3 (18.8)		
Moderately severe	111 (1.6)	1 (0.6)	6 (5.4)			94 (1.5)	1 (0.7)	3 (4.2)	7 (4.9)			62 (1.4)	1 (0.8)	3 (7.3)	-		
Severe	48 (0.7)	2 (1.3)	-			42 (0.7)	2 (1.3)	-	3 (2.1)			21 (0.5)	2 (1.5)	-	1 (6.2)		
Risky Drinker	3135 (45.4)	50 (32.3)	43 (39.1)	12.5	0.002	2845 (46.3)	49 (32.2)	30 (42.2)	52 (36.6)	17.4	0.001	2022 (45.73)	48 (36.6)	18 (43.9)	5 (31.3)	5.68	0.13
Current Smoker	2038 (29.5)	49 (31.6)	43 (39.1)	4.8	0.09	1828 (29.8)	49 (32.2)	29 (40.9)	45 (31.7)	4.5	0.213	1325 (30.0)	41 (31.3)	18 (43.9)	6 (37.5)	3.99	0.26

N = sample size; % = percent; X2 = likelihood ratio chi-squared; p = p-value

Table 4.9 Weighted bivariate associations between sexual orientation and food insecurity in women and men: National Health and Nutrition Examination Survey, 2005-2014

	Food insecure						Severely food insecure					
	Women			Men			Women			Men		
	% (SE)	X2	p	% (SE)	X2	p	% (SE)	X2	p	% (SE)	X2	p
Sexual Identity		17.28	<.001		3.47	0.04		15.47	<.001	5.9 (0.5)	3.23	0.05
Heterosexual	13.5 (0.6)			13.5 (0.6)			5.9 (0.4)			11.9 (4.0)		
Lesbian/Gay	26.7 (5.2)			19.2 (4.7)			14.2 (3.8)			8.7 (2.8)		
Bisexual	27.3 (3.3)			24.9 (5.5)			14.1 (2.2)			6.0 (0.5)		
Sexual Identity + Lifetime same-sex behavior		14.48	<.001		3.06	0.03		13.34	<.001		3.45	0.02
Heterosexual WSM / Heterosexual MSW	13.1 (0.6)			13.1 (0.6)			5.5 (0.4)			5.7 (0.5)		
Lesbian WSW /Gay MSM	27.4 (5.6)			19.2 (4.7)			15.3 (4.1)			12.1 (4.0)		
Bisexual WSW / Bisexual MSM	27.7 (3.6)			27.4 (7.2)			14.6 (2.4)			10.1 (3.9)		
Heterosexual WSW / Heterosexual MSM	20.8 (2.5)			17.7 (3.6)			11.8 (1.8)			10.1 (2.4)		
Sexual Identity + 12 month same-sex behavior		5.47	0.002		3.70	0.02		4.92	0.005		1.60	0.19
Heterosexual WSM / Heterosexual MSW	12.7 (0.6)			12.6 (0.7)			5.5 (0.4)			5.6 (0.5)		
Lesbian WSW /Gay MSM	27.3 (7.1)			17.2 (4.1)			12.3 (3.3)			9.7 (3.3)		
Bisexual WSW / Bisexual MSM	25.2 (5.4)			35.4 (11.2)			11.8 (3.6)			7.0 (4.3)		
Heterosexual WSW / Heterosexual MSM	19.7 (6.9)			24.8 (10.4)			10.7 (4.3)			15.4 (8.5)		

% = percent; SE = standard error; X2 = likelihood ratio chi-squared; p = p-value

Table 4.10 Weighted, adjusted logistic regression modeling associations between sexual orientation and food insecurity in adult women and men, using DAG-identified covariates: National Health and Nutrition Examination Survey, 2005-2014

	Model 1 Sexual Identity	Model 2 Sexual Identity + lifetime same-sex behavior	Model 3 Sexual Identity + 12 month same-sex behavior
	aOR (95% CI)		
Women			
Sexual Orientation			
Heterosexual / Heterosexual WSM	Ref	Ref	Ref
Lesbian / Lesbian WSW	**1.87 (1.10-3.19)**	**1.99 (1.10-3.61)**	**2.20 (1.11-4.36)**
Bisexual / Bisexual WSW	**1.69 (1.15-2.51)**	**1.79 (1.19-2.68)**	1.39 (0.73-2.65)
Heterosexual WSW	N/A	**1.56 (1.08-2.62)**	1.15 (0.47-2.81)
Poverty Level			
≥ 200%	Ref	Ref	Ref
< 200% (Poor/Near Poor)	**6.25 (5.28-7.41)**	**6.39 (5.34-7.64)**	**6.65 (5.51-8.02)**
Health Insurance			
Private	Ref	Ref	Ref
Public	**2.55 (2.13-3.05)**	**2.46 (2.05-2.95)**	**2.53 (2.05-3.11)**
None	**2.15 (1.73-2.68)**	**2.04 (1.63-2.54)**	**2.09 (1.63-2.68)**
	Model 1 Sexual Identity	Model 2 Sexual Identity + lifetime same-sex behavior	Model 3 Sexual Identity + 12 month same-sex behavior
Men	aOR (95% CI)		
Sexual Orientation			
Heterosexual WSM / Heterosexual MSW	Ref	Ref	Ref
Gay / Gay MSM	**2.13 (1.21-3.76)**	**2.17 (1.22-3.84)**	**2.09 (1.18-3.69)**
Bisexual / Bisexual MSM	1.80 (0.87-3.73)	2.08 (0.79-5.51)	2.86 (0.74-11.05)
Heterosexual MSM	N/A	1.30 (0.64-2.64)	1.33 (0.36-4.93)
Poverty Level			
≥ 200%	Ref	Ref	Ref
< 200% (Poor/Near Poor)	**4.97 (4.07-6.08)**	**5.18 (4.17-6.45)**	**4.76 (3.76-6.03)**
Health Insurance			
Private	Ref	Ref	Ref
Public	**3.33 (2.52-4.40)**	**3.29 (2.45-4.43)**	**3.44 (2.47-4.80)**
None	**3.21 (2.62-3.94)**	**3.24 (2.61-4.02)**	**3.23 (2.51-4.16)**

aOR = adjusted odds ratio; CI = confidence interval. Multivariable logistic regression analyses adjusted for the DAG-identified covariates minimally sufficient to estimate the direct association between sexual orientation and food insecurity.

Table 4.11 Weighted, adjusted logistic regression modeling associations between sexual orientation and severe food insecurity in adult women and men, using DAG-identified covariates: National Health and Nutrition Examination Survey, 2005-2014

	Model 1 Sexual Identity	Model 2 Sexual Identity + lifetime same-sex behavior	Model 3 Sexual Identity + 12 month same-sex behavior
	aOR (95% CI)		
Women			
Sexual Orientation			
Heterosexual / Heterosexual WSM	Ref	Ref	Ref
Lesbian / Lesbian WSW	**1.04 (1.01-3.73)**	**2.21 (1.11-4.40)**	1.95 (1.00-3.80)
Bisexual / Bisexual WSW	**1.86 (1.27-2.72)**	**1.86 (1.20-2.87)**	1.45 (0.72-2.90)
Heterosexual WSW	N/A	**2.01 (1.34-3.04)**	1.46 (0.58-3.68)
Poverty Level			
≥ 200%	Ref	Ref	Ref
< 200% (Poor/Near Poor)	**6.66 (4.88-9.09)**	**6.75 (4.92-9.27)**	**7.51 (5.13-11.00)**
Health Insurance			
Private	Ref	Ref	Ref
Public	**2.11 (1.65-2.70)**	**2.02 (1.58-2.58)**	**1.94 (1.45-2.60)**
None	**1.62 (1.19-2.20)**	**1.53 (1.12-2.08)**	**1.60 (1.14-2.24)**
	Model 1 Sexual Identity	Model 2 Sexual Identity + lifetime same-sex behavior	Model 3 Sexual Identity + 12 month same-sex behavior
	aOR (95% CI)		
Men			
Sexual Orientation			
Heterosexual / Heterosexual MSW	Ref	Ref	Ref
Gay / Gay MSM	**3.04 (1.53-6.05)**	**3.08 (1.55-6.13)**	**2.64 (1.23-5.69)**
Bisexual / Bisexual MSM	1.15 (0.53-2.52)	1.36 (0.51-3.58)	0.77 (0.21-2.90)
Heterosexual MSM	N/A	1.68 (0.81-3.48)	1.85 (0.39-8.74)
Poverty Level			
≥ 200%	Ref	Ref	Ref
< 200% (Poor/Near Poor)	**4.48 (3.31-6.06)**	**4.52 (3.34-6.12)**	**4.24 (2.87-6.26)**
Health Insurance			
Private	Ref	Ref	Ref
Public	**4.43 (2.72-7.22)**	**4.63 (2.77-7.74)**	**4.81 (2.74-8.44)**
None	**3.96 (2.80-5.59)**	**4.09 (2.90-5.75)**	**4.29 (3.01-6.12)**

aOR = adjusted odds ratio; CI = confidence interval. Multivariable logistic regression analyses adjusted for the DAG-identified covariates minimally sufficient to estimate the direct association between sexual orientation and severe food insecurity.

Chapter 5

Chronic Disease Disparities in Sexual Minority Populations: Concluding Thoughts on Patterns, Prevalence, and Determinants

Conclusion

Chronic diseases are leading causes of death and disability in the United States.[1,2] Sexual minority women (i.e., women who identify as lesbian or bisexual, or report same-sex behavior or attraction; SMW) and sexual minority men (i.e., men who identify as gay or bisexual, or report same-sex behavior or attraction; SMM) experience disproportionate risk for developing chronic diseases—including cancer, chronic lung disease, cardiovascular disease, and diabetes.[3] Yet, the breadth of chronic disease disparities across diverse groups of SMW and SMM is unknown.

Identifying patterns of chronic disease disparities and the population-level factors that give rise to these disparities in SMW and SMM is critical for developing tailored disease-reducing interventions. Smoking—a leading cause of chronic disease[4]—is a documented disparity in SMW and SMM.[5-12] While multiple studies have demonstrated that individual-level demographic and psychosocial risk factors are associated with smoking,[13-17] little is known about how social and economic determinants contribute to smoking in SMW and SMM. Food insecurity is a leading contributor to chronic disease disparities,[18] and is also associated with smoking in the general population.[19-24] Defined as "access by all people at all times to enough food for an active, healthy life",[25] food security is an economic determinant of health that may explain smoking disparities evidenced in SMW and SMM. Preliminary studies suggest that SMW and SMM are more likely to experience food insecurity;[26,27] however, no studies have considered whether food insecurity is driving smoking behaviors and, by extension, chronic disease in these populations.

Identifying prevalence and determinants of chronic disease in SMW and SMM is challenging, as population-level health surveillance programs that include measures of sexual orientation are not easy to identify. Moreover, sexual orientation is a multidimensional construct comprised of a person's sexual identity[28], attractions,[29] and behavior.[28] Measuring one or more of these dimensions captures unique subpopulations of SMW and SMM, who may exhibit differences in patterns and predictors of chronic disease disparities. For example, studies of smoking indicate that disparities are generally greater when sexual orientation is defined by sexual identity rather than sexual behavior or attraction. Smoking disparities also differ by sexual orientation subgroup (e.g., lesbian vs. bisexual women).[5-12,30] While best practices for measuring sexual orientation recommend assessing sexual identity, sexual behavior, and attraction,[31] identifying health surveillance programs that include more than one measure of sexual orientation is a persistent

challenge for sexual minority health researchers. This dissertation sought to document prevalence and determinants of chronic disease disparities in diverse subgroups of SMW and SMM, using population-level health surveillance and defining sexual orientation in terms of sexual identity and same-sex behavior.

Study Findings

Study 1 (Chapter 2) systematically reviewed the international, national, regional, and state-level health surveillance sources that included measures of sexual orientation. We then compared sexual orientation measures to best practices for sexual orientation measurement published by the Williams Institute.[31] A total of 43 publicly available surveillance data sources included measures of sexual orientation and health. Notably, approximately half of identified data sources included more than one measure of sexual orientation. This is promising as it allows researchers to identify invisible subgroups of sexual minority populations at the intersection of identity, and attraction, and/or behavior: For example, people who do not identify as LGB but experience same-sex attraction or sexual behavior. However, few health surveillance programs followed best practice recommendations for measuring sexual orientation: Only 14% of data sources included measures of all three dimensions of sexual orientation (identity, behavior, attraction); however, an additional 33% measured sexual identity and sexual behavior.

Data sources were not without limitations. Multiple data sources used double-barreled sexual orientation questions. For example, NHANES asks female respondents whether they define themselves as “Lesbian, that is you are attracted to women”. As such, it is not clear whether respondents are self-defining by their identity or attractions, which may have implications as we begin investigating mechanisms by which risk for chronic disease is conferred. There were also noticeable gaps by population and health data collected. Alarmingly, sexual orientation was restricted across some data sources to respondents aged 18-69, or in some cases, only up to age 59. This is problematic as sexual orientation is salient in late and older adulthood, and because chronic disease prevalence increases after age 60. As such, investigating chronic disease disparities across the lifecourse is hampered when sexual orientation questions are age restricted. Additionally, there were gaps in specialized areas, most notably in cancer statistics. For example, neither state cancer registries nor the Surveillance, Epidemiology, and End Results program—a national cancer surveillance program—measure sexual orientation. This limits what we know about cancer incidence and prevalence in SMW and SMM.

Study 2 (Chapter 3) investigated the distribution of chronic disease disparities in diverse subpopulations of sexual minority women and men. In this study, we used both sexual identity and sexual behavior measures to define SMW and SMM. Theoretical and empirical evidence suggest that defining sexual orientation with both sexual identity and sexual behavior measures reveals nuances about chronic disease patterns in hidden sexual minority groups—including heterosexual women and men who engage in same sex behavior (heterosexual WSW and heterosexual MSM).[32,33] Results unmasked specific disparities in chronic disease, even in an adult population < age 60 years old. These included disparities for SMW and SMM in chronic bronchitis—a chronic lower respiratory disease (CLRD)—and asthma. Asthma is also linked with later diagnosis of additional CLRDs, including chronic bronchitis and emphysema.[34] This is concerning as CLRDSs are the fourth leading cause of death in the United States.[1] Notably, chronic disease disparities were found even when controlling for smoking and obesity. Until this study, smoking and obesity were assumed to explain chronic disease disparities identified by studies that did not control for these variables.[3] In our models, estimates were reduced when smoking was included as a covariate, underscoring the influential role of smoking in chronic disease disparities. However, our results suggest that factors beyond smoking and obesity are contributing to chronic disease disparities in subgroups of SMW and SMM.

The final study (Chapter 4) investigated food insecurity as a determinant of smoking in SMW and SMM. Because little is known about food insecurity in SMW and SMM, this manuscript also investigated food insecurity experienced by diverse subgroups of SMW and SMM; that is, those defined by identity only and in terms of sexual identity and sexual behavior (12 month and lifetime). Gender-stratified analyses indicated that food insecurity was associated with current smoking in SMW defined by sexual identity and lifetime sexual behavior. Moreover, when sexual orientation was defined by sexual identity and behavior, SMW who experienced food insecurity or severe food insecurity reported smoking more cigarettes per day than food secure SMW. Among men, severe food insecurity was associated with current smoking only. Our findings are consonant with the existing literature.[19,22,35] In studies using comprehensive measures of food security, food insecure adults (vs. food secure adults) are 1.5-3.8 times more likely to report current smoking.[19,22,35] One limitation of our study and others[20,21,23,24,35] is that cross-sectional data limit our understanding of causal relationships between food insecurity and smoking. It may be that smoking is an “opportunity cost” such that smokers forgo food in order to preserve disposable income to purchase cigarettes.[23,24] In this case, smoking is hypothesized to cause food insecurity. However, two longitudinal studies suggest that food insecurity is

causally associated with smoking. In the first study, nonsmokers who became food insecure by follow-up were over 3 times as likely to start smoking.[19] In a second cohort study of low income women, food insecure women (vs. food secure women) were 68% more likely to report smoking over time.[22] In light of our results, published longitudinal studies, and in accordance with fundamental cause theory, we hypothesize that inequitable social conditions give rise to depleted social and economic resources (e.g., food insecurity) in SMW/SMM, which increases risky behaviors (e.g., smoking). However, future longitudinal studies are needed to test the pathways that may explain these associations.

In our second set of analyses, we investigated prevalence of food insecurity and severe food insecurity in women and men, by sexual orientation subgroup. Remarkably, when sexual orientation was defined by sexual identity or in terms of sexual identity and lifetime sexual behavior, all subgroups of SMW evidenced disparities in food insecurity and severe food insecurity. However, when sexual orientation was defined in terms of sexual identity and 12-month sexual behavior, only lesbian WSW were more likely to report experiencing food insecurity. Gay men and gay MSM were also more likely to report experiencing food insecurity and severe food insecurity, no matter how sexual orientation was defined. Until our study, existing evidence provided a mixed picture of food insecurity in sexual minority communities. While an original Williams' Institute report indicated gender-based disparities in food insecurity (defined as lack of money to buy food),[27] a second report using a United States Department of Agriculture (USDA) endorsed measure of food insecurity did not evidence food insecurity disparities in sexual minorities in general nor gender-stratified estimates.[26] Our results extend the existing epidemiological literature by documenting gender-based food insecurity disparities in diverse subgroups of SMW and SMM, using a comprehensive, USDA endorsed measure of food insecurity.

Minority Stress and Sexual Minority Health Disparities

In studies 2 and 3 (Chapters 3 and 4), we determined that subgroups of SMW and SMM evidenced disparities in food security, smoking, and chronic disease—even when controlling for known economic and psychosocial risk factors. Minority stress theory proposes that SMW and SMM experience excess stress arising from sexual orientation-related discrimination.[36] Minority stress is structural, interpersonal, and internalized.[36] It exists beyond an individual's control, is chronic in nature, and accumulates across the life course.[36] When we consider minority stress in the context of fundamental cause theory,[37,38] structural minority stress is considered a

fundamental cause of health disparities. That is, social and policy environments that do not protect or, worse, actively penalize people based on sexual orientation engender inequitable social conditions for SMW and SMM that lead to poorer health outcomes.

Multiple hypotheses explain how minority stress is a fundamental cause of health disparities in SMW and SMM. At a structural level, minority stress arising from inequitable social conditions is hypothesized to result in depleted social and economic resources—including poverty, un- and under-employment, and decreased healthcare access. Minimal research documents poverty estimates for sexual minority populations.[39-41] Yet, the existing literature indicates economic disparities for SMW and SMM. Compared to 5.7% of married heterosexual households, 4.3% of male same-sex households and 7.6% of female same-sex household are living in poverty.[40] Alarmingly, 23.4 % of male same-sex couples and 19.2% of female same-sex couples are also raising children in poverty (vs. 12.1% married heterosexual couples). Economic disparities are further exacerbated for sexual minorities of color[40,41] and those living in conservative or Southern states.[39,40,42] For sexual minorities living in states without nondiscrimination protections, employment discrimination and lower insurance rates further compound financial strain.[40,42,43] For example, more female same-sex couples living in states without nondiscrimination policies are likely to be poor (9.2%) than those living in states with non-discrimination policies (5.6%).[40] Together, poverty, under- and unemployment, and lack of insurance, create substantial economic barriers to healthcare for SMW and SMM.[44] Discrimination by healthcare providers further decreases access,[45,46] leading SMW and SMM to avoid healthcare for fear of victimization.[46-48] Sexual minority adults in our second study (Chapter 3) were more likely to report being diagnosed with a chronic disease than heterosexual adults; this may reflect healthcare access barriers that prevent SMW and SMM accessing routine preventive care that may mitigate the development of chronic disease.

It may also be that SMW and SMM are more likely to cope with sexual orientation-related discrimination by engaging in health risk behaviors—such as smoking—leading to tobacco-related disease disparities (i.e., chronic bronchitis, asthma, hypertension) evidenced in our second study (Chapter 3). Multiple studies indicate that young SMW and SMM living in highly inequitable environments (e.g., those with few policy protections for sexual minorities, few LGBT resources, or more residents with poorer attitudes toward LGBT people) are more likely to report current smoking than those living in more equitable states.[49-51] Moreover, in a recent qualitative study, LGBT community leaders noted that sexual minorities in their communities

experience multiple minority stressors, which lead to unhealthy coping (i.e., smoking).[52] Together, these studies indicate that structural minority stress may drive smoking behaviors in sexual minorities, ultimately leading to chronic disease disparities.

A final hypothesis linking minority stress and health disparities is that experiencing minority stress leads to physiological changes, resulting in chronic inflammation that magnifies risk for disease development. At a biological level, experiencing excess stress may contribute to cortisol dysregulation. Cortisol is a biomarker of allostatic load, or the "long-term negative effects on the body that accumulate in response to chronic stress.[53] Experiencing stressors trigger the release of cortisol, which activates the hypothalamic pituitary adrenal (HPA) axis, our body's stress response system.[53] Under prolonged or repeated stressful conditions, the HPA axis is continually activated, leading to allostatic load and elevated inflammation.[54] Under these conditions SMW and SMM may develop inflammatory diseases,[55] such as those evidenced in our second study (Chapter 3; i.e., arthritis, asthma, and chronic bronchitis). Emerging evidence supports this hypothesis. In a study of young adults, experiencing high levels of structural stigma (i.e., discriminatory social norms and policy directed toward sexual minorities) was associated with disruption of the HPA axis, affecting cortisol regulation.[56] Further studies investigating interpersonal discrimination indicate that interpersonal minority stress is associated higher diurnal cortisol levels, indicating changes in HPA-axis functioning in young adults.[57]

Physiological differences in response to minority stress may also explain gender-based differences in chronic disease. In general, men are more likely to exhibit higher cortisol levels in response to stress.[58] In response to stress, however, gay and bisexual men indicated a blunted cortisol response than heterosexual men.[59] However, in the same study, lesbian and bisexual women demonstrated higher stress reactivity and cortisol levels than heterosexual women.[59] Lesbian and bisexual women's cortisol response was also delayed, such that cortisol levels took longer to peak and, thus, longer to stabilize after experiencing stress.[59] Together, these studies suggest that experiencing chronic structural or interpersonal-level minority stress may increase cortisol production, leading to repeated HPA-axis stimulation. For women, especially, this dysregulated stress response may lead to increased allostatic load and inflammations, explaining increased disparities in inflammatory chronic diseases evidenced for SMW in our second study.

It is also likely that structural minority stress contributes to food insecurity disparities evidenced in Study 3 (Chapter 4). To our knowledge, no published reports present a state-by-state analysis of food insecurity in sexual minority populations. However, as aforementioned, SMW and SMM living in states without sexual orientation-based nondiscrimination policies are more likely to experience poverty. Consequently, sexual minorities living in these states may have less disposable income to meet basic needs—including food.[40] It is also possible that sexual minorities living in conservative areas are less likely to seek food assistance from food pantries or soup kitchens. Regional studies suggest that many community-based assistance programs are religiously affiliated.[60-64] However, a recent study of Southern-located food insecure transgender and gender non-conforming people (TGNC) indicated that respondents were hesitant to seek food assistance from religiously-affiliated food pantries.[65] Similarly, SMW and SMM may also be less likely to access religiously-affiliated food pantries due to fear of spiritual violence.[66]

A second hypothesis is that SMW and SMM living in “equitable” states may also experience food insecurity tangentially driven by structural discrimination. Historically, groups of SMW and SMM established urban enclaves, or “gayborhoods” in U.S. coastal port cities. The relocation of sexual minorities to these urban areas was largely driven by community needs for acceptance and safety in the face of sexual orientation-related discrimination.[67] Density of LGBT people and same-sex couples is still higher in these “equitable” states,[39] where cost of living also tends to be higher.[68] It could be that SMW and SMM living in “equitable but expensive” areas spend more money covering basic expenses (e.g., taxes, housing, and transportation), leaving less money to spend on food. If this is true, inequitable conditions may drive SMW and SMM to live in more “equitable but expensive” states, where high cost of living increases risk for experiencing food insecurity.

Gendered Patterns of Sexual Minority Health Disparities

Our studies suggest that SMW disproportionality experience specific health disparities: In study 2 (chapter 3), SMW reported disparities across more chronic diseases than SMM, including arthritis, asthma, and chronic bronchitis. In study 3 (chapter 4), all SMW reported disparities in food insecurity, while only gay men/gay MSM evidenced food insecurity disparities. Moreover, food insecure and severely food insecure SMW were more likely to currently smoke and reported smoking more cigarettes per day than food secure SMW. In contrast, food insecurity was only associated with current smoking for SMM reporting severe food insecurity. One

explanation for the breadth of disparities evidenced by SMW in our studies is that intersectional oppression (i.e., oppression arising from sexual orientation *and* gender) confers disproportionate risk for food insecurity, smoking, and chronic disease. According to Meyer (2010) at the "core of stress theory is a simple premise: Members of minority groups are *disadvantaged* in multiple ways in society" (emphasis added).[69,p.448] Seminal minority stress theory reflects this idea of intersectionality as disadvantage.[70] Multiple social identities intersect, placing SMW at-risk for experiencing interlocking, systemic discrimination and oppression.[71,72] For example, in society where being White, heterosexual, and male confers privilege and power, a Latinx SMW may experience sexism, homophobia, and xenophobia arising from the intersection of her multiple identities. In sexual minority communities, she may face sexism and xenophobia. In the Latinx community, she may face sexism and homophobia.

The early minority stress literature suggests that the cumulative effect of intersectional identities and oppression results in excess stress for SMW, which magnifies risk for engaging in in risk behaviors (e.g., smoking) and results in poor health outcomes (e.g., chronic disease).[36] However, this risk hypothesis is an oversimplification of the dynamic relationships between intersectional identities, stress, and health. Later scholars extend the minority stress model to include a resilience hypothesis wherein intersectional identities buffer the relationship between minority stress and health.[69,71,73] In this case, a SMW's sexual orientation is viewed as but one component part of a complex, gendered identity structure, such that the prominence of her sexual minority identity is diffused and sexual orientation-specific stressors may exert less influence on health. Research within diverse racial/ethnic sexual minority groups supports this idea. People of color (POC) who also identify as sexual minorities may not experience amplified internalized homophobia compared to white sexual minorities.[74] These results suggest a resilience hypothesis wherein POC sexual minorities, having experienced racism prior to "coming out" as a sexual minority, may be "inoculated" against minority stress in a way white sexual minorities are not.

Feminist scholars have articulated the concept of intersectional oppression as "gendered racism" in studies of Black women's health.[72,75,76] The concept of gendered racism considers race and gender as inextricably connected such that Black women experience unique oppression and discrimination due to their interlocking identities as Black and female.[70] More recently, this work has extended to research examining POC sexual minorities.[77] In both research areas, experiencing intersectional oppression is linked with increased psychological

distress; however, these studies to not investigate how intersectional oppression confers excess risk for resource loss and subsequent poor health as suggested by fundamental cause theory.[75,77]

Few health studies examine similar concepts in SMW. However, feminist scholars have considered how "gendered homophobia" influences employment discrimination experienced by SMW.[78-81] In these studies, SMW's gender expression (i.e., appearance, mannerisms, and behavior associated with femininity and masculinity[82]) and sexual orientation confer excess risk for experiencing sexism and heterosexism in the workplace. In SMW, gender expression is often categorized on a spectrum from more feminine gender expressions (i.e., "femme", "lipstick") to more masculine gender expressions (i.e., "butch", "dyke", "stud", boi").[82-85] SMW may also express their gender more androgynously (i.e., "androgynous", "genderqueer", "gender non-conforming", "nonbinary", "sporty", "tomboi").[82-85] In qualitative studies, SMW attribute employment discrimination to intersectional oppression based on sexual orientation, gender, and gender expression. Androgynous or butch SMW report being denied employment despite holding higher qualifications.[78,79] They are also more likely to report experiencing on-the-job- discrimination and hostile work environments due to their masculine gender expression, which male coworkers find threatening.[78-80] More generally, SMW describe being offered lower salaries than male coworkers, and facing limited promotion and employment opportunities.[78,79,81] SMW's workplace experiences are essential to understanding how social inequities contribute to poverty and related resource deprivation (e.g., food insecurity disparities evidence in Chapter 4).

Applying fundamental cause theory, the greater structural discrimination experienced by SMW disproportionately depletes their social and economic resources, which may increase their susceptibility to food insecurity in comparison to SMM. Evidence indicates that SMW face economic disparities arising from workplace discrimination, lower health insurance rates, and historical lack of access to marriage-related tax and financial benefits.[40] Based on the extant literature documenting SMW's experiences of intersectional sexism and heterosexism (i.e., gendered heterosexism),[78-81] it is likely that gendered heterosexism negatively influences employment opportunity and job stability, contributing to insecure wages and poverty.

While little evidence documents poverty in SMW, studies indicate that SMW consistently earn less than SMM despite actively contributing to the workforce.[40] Moreover, compared to

heterosexual women, SMW are more likely to report incomes < 200% of the federal poverty line (poor or near poor).[40,41] These disparities are exacerbated for SMW of color[86] and rural SMW,[40] supporting our assumption that intersectional oppression diminishes SMW's access to economic and social resources that might alleviate risk for experiencing food insecurity. In studies of TGNC people, employment discrimination based on gendered heterosexism was reported as a driving factor of poverty and subsequent food insecurity.[65] If the same experiences hold true for SMW, decreasing food insecurity disparities will require addressing inequitable social conditions specific to sexual orientation, gender, and the intersection of these identities.

Gendered heterosexism may also contribute to chronic disease disparities in SMW. In our third study (Chapter 4), SMW were more likely than SMM and heterosexual women to experience food insecurity. Food insecurity is associated with chronic disease in the general population.[23,87,88] Results from study 3 (Chapter 4) suggest that food insecurity is associated with current smoking and smoking intensity in SMW. As such, gendered heterosexism may be driving chronic disease disparities in SMW through its influence on food insecurity and subsequent cigarette smoking. This hypothesis could explain the disproportionate respiratory disease disparities evidenced in SMW in study 2 (Chapter 3) and should be tested future studies using retrospective or prospective longitudinal designs.

It may also be that gendered heterosexism negatively effects healthcare access, decreasing SMW's likelihood of receiving preventive care. For example, butch SMW report difficulty finding an LGBT-friendly healthcare provider, are more likely to receive poor treatment from healthcare providers, and are less likely to seek medical advice than femme SMW.[89] Similarly, for gender non-conforming SMW, healthcare providers' "confusion" about their gender and stigmatizing healthcare encounters are reported as a driving factors for avoiding future healthcare despite health needs.[90] Together, these studies suggest that gendered heterosexism may negatively influence healthcare access for SMW with more androgynous or masculine gender expressions. For these SMW, healthcare avoidance and limited preventive care may negatively affect chronic disease development and contribute to population-level disparities evidenced in our second study (Chapter 3).

In our third study (Chapter 4), when sexual orientation was defined by sexual identity and behavior, food insecure SMW were more likely to report current smoking and increased daily

smoking than food secure SMW. However, food insecurity was not associated with smoking behaviors for SMM, no matter how sexual orientation was defined. One explanation is that sample sizes of SMW smokers were larger than heterosexual SMM smokers (n = 290 vs. n = 123, respectively). Thus, the larger sample size increased our power and ability to detect an effect in regression analyses of food insecurity and smoking in SMW.[91]

However, gendered heterosexism may also negatively contribute to cigarette smoking in SMW. For decades the tobacco industry has targeted low income women[92] using advertising campaigns that emphasize smoking as a tool for stress relief, mood regulation, and weight loss.[93] Simultaneously, the tobacco industry has directly targeted sexual minorities through direct advertising in LGBT publications, outreach efforts (e.g., tobacco-sponsored LGBT bar nights), and event sponsorships (e.g., LGBT film festival and PRIDE sponsorships).[94]

Food insecure SMW experience the tobacco industry at the intersection of both of these identities (i.e., by gender and sexual orientation), which may increase their susceptibility to tobacco industry advertising. There is some evidence to support this hypothesis. In one study, compared to heterosexual women, SMW were 1.7-1.9 times more likely to attend events that included free samples or coupons for tobacco products. They were also 1.6-1.9 more likely to own a product with a tobacco industry logo and were 1.6-.2.0 times more likely to report that they would use or wear tobacco industry merchandise.[95] SMW's disproportionate exposure to tobacco industry advertising begins early: A recent study of adolescent sexual minorities indicated that young SMW were more likely to be exposed to online tobacco marketing than heterosexual young women.[96] Of young SMW exposed to tobacco marketing, most read articles, watched videos, or liked or followed a tobacco brand on social media.[96]

SMW's increased exposure to and acceptance of tobacco industry marketing is especially concerning as tobacco advertising exposure is associated with over thrice the odds of cigarette smoking in SMW.[15] The tobacco industry also circumvents cigarette access issues by offering point-of-sale and direct mail coupons to offset costs to low income women.[92] In their study of online exposure to tobacco couponing, Emory and colleagues (2018) determined that LGBT people were more likely to search for and share online tobacco discounts and coupons than non-LGBT people.[97] As such, food insecure SMW may view cigarette smoking as a financially accessible coping strategy—whether to manage stress or curb hunger. Future research

examining pathways between food insecurity and smoking in SMW are needed to answer this question.

Hidden Sexual Minority Subpopulations and Health Disparities

Our study used multiple measures of sexual orientation to define sexual minorities in terms of sexual identity and sexual behavior. By doing so, we were able to measures distinct and hidden subgroups of SMW (lesbian WSW, bisexual WSW, heterosexual WSW) and SMM (gay MSM, bisexual MSM, and heterosexual MSM). Interestingly, health disparities differed in heterosexual WSW and heterosexual MSM. For example, in study 2 (Chapter 2), heterosexual MSM evidenced disparities in asthma, while heterosexual WSW did not evidence any chronic disease disparities.

One explanation is that heterosexual WSW may differently experience social determinants of chronic disease—including minority stress. For example, compared to heterosexual MSM, heterosexual WSW may be less likely to fear or experience discrimination for engaging in same-sex behavior in a culture that sexualizes sexual contact between women for men's pleasure.[98] Bisexuality and bisexual sexual behavior in women has become increasingly "mainstreamed" via popular culture. Research suggests that same-sex behavior between women is both accepted and desired by heterosexual men,[99] as such, the proliferation of "girl-on-girl" sexual behavior in television shows, movies, and music may reflect the mainstreaming of male desire. Media representation of female bisexuality may also confer "acceptance" of bisexuality in women. In her discussion of "compulsory bisexuality", Fahs (2009) notes:

> "Women's sexuality shifts in response to changing social trends and pressures more readily than men's sexuality… such plasticity may make (temporary or transient) bisexual identification possible, as women internalize messages that it is okay for them to experiment sexually with other women."

The tacit acceptance of female bisexuality conveyed by the media may decrease women's apprehensions about experiencing discrimination for acting on their desires—especially in the context of men's desire (i.e., heterosexual relationships). This phenomenon has been explored in studies of "performative bisexuality" where women report publicly engaging in same-sex encounters—often for men's enjoyment.[100,101] In contrast, studies indicate that male bisexuality and bisexual behavior is not accepted[102-104] and that heterosexual men are less accepting of

bisexuality.[105] Future research that includes measures of multilevel sexual orientation-related discrimination and the internalization of these stressors is needed to understand which factors buffer chronic disease disparities in heterosexual WSW and engender disparities in heterosexual MSM.

In contrast to our findings on chronic disease, heterosexual WSW evidenced disparities in food security while heterosexual MSM did not. Heterosexual WSW may be more likely to experience sexism affecting social and economic resources, including employment and income. In our sample a similar proportion of heterosexual WSW and heterosexual MSM reported incomes < 200% FPL (35.6 % vs. 36.0%, respectively); however, a larger proportion of heterosexual WSW in our sample reported incomes between 200-299% FPL (15.1%) than heterosexual MSM (4.1%). Individuals with incomes > 200% FPL typically do not qualify for government food assistance programs, which are designed to alleviate food insecurity.[106] However, they may still experience financial strain that makes affording food challenging.[107] It may also be that food is differently allocated between women and men in heterosexual partnerships, such that partnered heterosexual WSW are more likely to eat less or skip meals than partnered heterosexual MSM. Finally, there is evidence of gender-differences in reporting food security in population-based surveys,[108] which may also contribute to differences in food insecurity reported by heterosexual WSW and heterosexual MSM.

As aforementioned, in our third study (Chapter 4), all SMW experienced disparities in food insecurity. However, differences emerged by sexual orientation subgroups such that the magnitude of the effect was greater for lesbians and lesbian WSW, no matter how sexual orientation was defined. In our second study (Chapter 3), lesbians evidenced disparities across more chronic diseases than bisexual women or heterosexual WSW. Moreover, for diseases for which both lesbian and bisexual women evidenced disparities (i.e., arthritis and asthma), the magnitude of the effect was greater for lesbians.

Our results indicate that lesbians and lesbians WSW exhibit disproportionate risk for chronic disease. It is possible that subgroups of lesbian, bisexual and heterosexual SMW differently experience gendered heterosexism, and this may explain differences across subgroups. However, observational, mixed-methods studies are needed to better understand how gendered heterosexism and other multilevel factors (e.g., economic stability, food insecurity, stress coping) influence health in diverse subgroups of SMW. Finally, results across these studies

underscore that researchers must use multiple measures of sexual orientation in epidemiological studies to identify patterns of health disparities in high-risk sexual minority subgroups that we may need to address with tailored interventions.

Future Implications

Understanding patterns and determinants of chronic disease disparities is essential for improving health and health equity for SMW and SMM. However, our ability to identify and monitor sexual minority health disparities is limited by the lack of comprehensive sexual orientation measurement in publicly available health surveillance. Over the past two decades, we have seen progress in the number of U.S. health surveillance programs that have added at least one measure of sexual orientation to health surveys. However, national efforts to track sexual minority health disparities have diminished under the recent Trump Administration leadership. In 2017, plans to collect national sexual orientation data were derailed after questions were removed from major surveys including the 2020 Decennial Census, American Community Survey, National Survey of Older Americans Act Participants, and Annual Program Performance Report for the Centers for Independent Living. The exclusion of sexual orientation from these surveys is devastating to sexual minority communities, as the federal government uses data from these sources to prioritize and allocate funding.

For researchers, excluding sexual orientation questions also affects our science. Without accurate Census counts, it is impossible to determine the correct statistical weighting for SMW and SMM included in national health surveillance. In the absence of population-specific weighting, we cannot be sure that statistical estimates accurately reflect disparities evidenced in diverse sexual minority populations. As such, we must rely on pooled estimates across national and regional studies to approximate the breadth of health disparities experienced by SMW and SMM. Doing so may lead to over- or underrepresentation of health disparities—especially in areas where existing data collection is limited, as with older adults.

This series of studies suggests that subgroups of SMW and SMM < 60 years old experience health disparities, and that patterns of disparities differ depending on how sexual orientation is defined. In study 2 (chapter 3), subgroups of lesbian and bisexual women, as well as gay and heterosexual MSM evidenced disparities in respiratory and inflammatory chronic diseases—including asthma, chronic bronchitis, arthritis, and hypertension. In study 3 (chapter 4), all subgroups of SMW and gay men/gay MSM experienced food insecurity disparities. However,

association between food insecurity and smoking (current smoking and smoking intensity) were only determined for SMW defined by sexual identity and sexual behavior. Only half of all publicly available health surveillance programs assess sexual orientation with more than one measure (i.e., identity, behavior, or attraction). However, without measuring sexual orientation with multiple measures we would know nothing about disparities in hidden subgroups of heterosexual WSW and heterosexual MSM. This affects our ability to develop tailored disparities-reducing interventions for these populations.

Our studies also suggest that SMW bear a disproportionate burden of food insecurity and chronic disease disparities. While multiple systematic and scoping reviews[109-116] and two National Academies' reports[3,117] document a breadth of psychosocial and physical health disparities in SMW, SMW's health is vastly understudied. A systematic review of National Institutes of Health (NIH)-funded studies between 1989-2011 indicated substantial deficits in support for SMW health research. Of 628 NIH-funded studies, only 13.5% (n = 85) focused on SMW's health. Funding deficits were also apparent by type of study such that only 6% of NIH-funded intervention studies involved SMW. Of greater concern, while the number of NIH-funded grants focused on SMM increased over time, grants investigating SMW's health did not experience substantial increases. The limited growth in NIH-funded SMW health research is especially concerning. SMW comprise a growing proportion of the sexual minority population[118] that experiences substantial risks for morbidity and mortality.[119-124] As such funding SMW's health research is a public health priority.

Our studies indicate that SMW and SMM experience disparities in food insecurity and chronic disease and that, for SMW, food insecurity may be contributing to smoking behaviors. Fundamental cause theory and minority stress theory suggest that structural oppression and discrimination are social determinants of health disparities. At this time, SMW and SMM are not protected against sexual orientation-based discrimination in over 50% U.S. states. This gap in employment, healthcare, and public accommodations may be driving disparities evidenced in this dissertation—and other studies.[3] However, future population-level studies, using multilevel methods and state-by-state policy analysis are needed to better understand how structural minority stress is associated with chronic disease, smoking, and food insecurity.

Ultimately, increasing health equity for SMW and SMM requires multilevel solutions—including LGBT-affirmative federal, state and local policies; organizational policy and training; and local

solutions to increase access to employment, healthcare, social services (e.g., food assistance programs). Of these, advancing LGBT civil rights protections through federal and state nondiscrimination laws must be a public health priority. National polls indicate that in every state, a majority of Americans support laws protecting sexual minorities from discrimination in employment, public accommodations, and housing.[125] To date, almost 50% of states have nondiscrimination laws in these areas.[126] Yet, growing public support has not resulted in safer communities for sexual minorities. Between 2012 and 2017, the number of reported anti-LGBT homicides doubled.[127] Between 2012 and 2016, charges of SOGI discrimination reported to the Equal Employment Opportunity Commission increased ten-fold in states without nondiscrimination laws (2012: n = 126; 2016: n = 1213). In states *with* nondiscrimination policies, SOGI discrimination charges also doubled during this time (2012: n = 508; 2016; n = 1063).[128] In 2015, sexual minorities living in Southern states where nondiscrimination policies are less prevalent were three times as likely to repot experiencing online sexual orientation-related harassment.[129] States lacking nondiscrimination policies systematically disadvantage sexual minorities and place them at increased risk for interpersonal violence. Especially in these states, we—as public health researchers and activists—must lead the charge to increase comprehensive civil rights for all LGBT people. Only then will we begin to achieve health equity for this group.

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Vita

Joanne Gayle Patterson was born in Berwick-upon-Tweed, England to Margaret and Ronald Patterson. In 2000, she graduated from Columbus High School (Columbus, GA) before attending Wesleyan College in Macon, GA. There she studied English (major) and Psychology before graduating with her B.A.in English (2004). Joanne moved to Boston, Massachusetts to study nonprofit program development and evaluation at Boston University School of Social Work where she enrolled in a dual degree Master's program at the Boston University School of Public Health. Joanne completed a Master's in Social Work (Macro concentration) in 2004 and a Master's in Public Health (Social and Behavioral Sciences concentration) in 2007. For almost a decade, Joanne worked for Boston-area nonprofit organizations developing, implementing, and evaluating lesbian, gay, bisexual, transgender, and queer (LGBTQ)-inclusive, community-based dating and domestic violence prevention programs. She then decided to pursue a research career where she could apply her knowledge and skills to population-level health. At the University of Tennessee, Joanne's research focused on social and environmental determinants of health in LGBTQ populations. To this end, she led and collaborated on multiple exploratory qualitative studies, observational studies of pre-existing health surveillance, and feasibility studies of behavioral interventions.

Ultimately, Joanne defines herself as a health equity researcher. Her research focuses on identifying multilevel determinants of chronic disease and cancer-related health inequities in women and LGBTQ people, and testing interventions to improve health. She will continue this work as a postdoctoral fellow at the Ohio State University-James Comprehensive Cancer Center in their T32 training program in Cancer Prevention and Control. There she will contribute to an implementation study of a smoking cessation intervention for rural women delivered through primary care clinics in Appalachia. She also plans to further her LGBTQ health equity research by investigating multilevel determinants of smoking in lesbian and bisexual women and then developing and feasibility testing a targeted, online cessation program.