BMJ Open

We are complex beings: comparison of statistical methods to capture and account for intersectionality

Brooke A Levandowski ,[1] George C Pro,[2] Susan B Rietberg-Miller,[1] Ricky Camplain[3]

To cite: Levandowski BA, Pro GC, Rietberg-Miller SB, *et al*. We are complex beings: comparison of statistical methods to capture and account for intersectionality. *BMJ Open* 2024;**14**:e077194. doi:10.1136/bmjopen-2023-077194

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2023-077194).

Received 10 July 2023
Accepted 10 January 2024

[1]Obstetrics & Gynecology, University of Rochester Medical Center, Rochester, NY, USA
[2]University of Arkansas for Medical Sciences, Little Rock, Arkansas, USA
[3]Epidemiology and Biostatistics, Indiana University, Bloomington, Indiana, USA

Correspondence to
Dr Brooke A Levandowski; brooke_levandowski@urmc.rochester.edu

ABSTRACT

Objectives Intersectionality conceptualises how different parts of our identity compound, creating unique and multifaceted experiences of oppression. Our objective was to explore and compare several quantitative analytical approaches to measure interactions among four sociodemographic variables and interpret the relative impact of axes of marginalisation on self-reported health, to visualise the potential elevated impact of intersectionality on health outcomes.

Design Secondary analysis of National Epidemiologic Survey on Alcohol and Related Conditions-III, a nationally representative cross-sectional study of 36 309 non-institutionalised US citizens aged 18 years or older.

Primary outcome measures We assessed the effect of interactions among race/ethnicity, disability status, sexual orientation and income level on a self-reported health outcome with three approaches: non-intersectional multivariate regression, intersectional multivariate regression with a single multicategorical predictor variable and intersectional multivariate regression with two-way interactions.

Results Multivariate regression with a single multicategorical predictor variable allows for more flexibility in a logistic regression problem. In the fully fitted model, compared with individuals who were white, above the poverty level, had no disability and were heterosexual (referent), only those who were white, above the poverty level, had no disability and were gay/lesbian/bisexual/not sure (LGBQ+) demonstrated no significant difference in the odds of reporting excellent/very good health (aOR=0.90, 95% CI=0.71 to 1.13, p=0.36). Multivariate regression with two-way interactions modelled the extent that the relationship between each predictor and outcome depended on the value of a third predictor variable, allowing social position variation at several intersections. For example, compared with heterosexual individuals, LGBQ+ individuals had lower odds of reporting better health among whites (aOR=0.94, 95% CI=0.93 to 0.95) but higher odds of reporting better health among Black Indigenous People of Color (BIPOC) individuals (aOR=1.13, 95% CI=1.11 to 1.15).

Conclusion These quantitative approaches help us to understand compounding intersectional experiences within healthcare, to plan interventions and policies that address multiple needs simultaneously.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ While the majority of intersectionality research tests sex/gender and/or age/generation comparisons, few compare methodologies and apply four different marginalised identities within the same dataset, while addressing the call for using intersectional frameworks in public health.
⇒ The large sample size allows for the significant findings in the interpretation of two-way interactions and within-group comparisons that exist, highlighting the important contributions of disability status, sexual orientation and race/ethnicity in self-reported health.
⇒ The major limitation of this study is the use of older data and smaller sample sizes of less than 1% in 7 of the 16-level categorical predictor model.

INTRODUCTION

Arising from critical race theory and black feminist theory, intersectionality conceptualises how different parts of our identity compound to create unique and multifaceted experiences of oppression.[1] Intersectionality necessitates capturing and including complexities of experience and identity that contribute to oppression and marginalisation, including, but not limited to, race, ethnicity, sexual orientation, income and disability, and interpreting findings through a lens of structural power inequities.[2] While associations between self-reported health and characteristics that make up our identity, such as income or socioeconomic status,[3 4] race and ethnicity[3 5 6] and sexual orientation,[7] have been well established, they are traditionally explored separately in epidemiological research. Specifically, traditional quantitative statistical approaches do not dictate how to effectively create and define intersectional variables that more fully encompass the lived experiences of race/ethnicity, sexual orientation, income and disability, and how they intersect and interact to affect various measures of health.

Intersectionality theory was not originally created in the context of epidemiological practice or research, and was not designed to quantify, predict or identify health inequities.[8] However, intersectionality is being increasingly identified as an important theoretical framework for epidemiology and health inequities research.[8 9] Various attempts have been made to incorporate intersectionality into quantitative research methods; however, nascent explorations have primarily relied on additive models, which undermine the rich matrix of experience that exists, for example, for a Hispanic lesbian female, and not each identity separately.[6 9–11] More research needs to be done to address reoccurring limitations, appropriately using multiplicative models and contextualising findings with a structural power lens.[3–5 7 8 12]

Our objective was to illustrate the power of quantitative intersectional analyses by comparing two different quantitative intersectional analytical approaches to a baseline non-intersectional approach. Our analyses directly respond to Bowleg's call to apply intersectionality within public health, by measuring interactions among four sociodemographic variables detailed in the article—specifically race/ethnicity, income, sexual orientation and disability status.[2] We interpreted the relative impact of axes of marginalisation on self-reported health, in order to visualise the potential elevated impact of intersectionality on health outcomes opposed to the effect of each variable alone.

METHODS

Data source

We used data from the National Epidemiologic Survey of Alcohol and Related Conditions—III (NESARC-III) (April 2012 to June 2013; n=36 309) to assess self-reported health. The development and sampling methods of NESARC-III have been described extensively elsewhere.[13] In short, NESARC-III provides individual-level survey data on topics ranging from substance use and mental health disorders, health services utilisation and many unique social and cultural characteristics. NESARC-III uses a complex sampling design; we used provided sample weights and strata in analyses. Access to NESARC-III was granted to the study team by the National Institute on Alcohol Abuse and Alcoholism.[13 14] All analyses were conducted in SAS (V.9.4). This paper was prepared using the Strengthening the Integration of Intersectionality Theory in Health Inequality Analysis (SIITHIA) checklist.[15]

Patient and public involvement

Patients and/or the public were not involved in the study.

Positionality statement

In accordance with the SIITHIA checklist, our research team has disciplinary backgrounds in epidemiology, health services research, health equity research and community based participatory research. We come from diverse economic, racialised, sexual orientation and gender identity backgrounds.

Variables

NESARC variables were collected by interviews. Respondents were asked if they 'are of Hispanic or Latino origin', with yes/no response options. Respondents were given a card with racial categories (white, Black or African American, Asian, Native Hawaiian or Other Pacific Islander, American Indian or Alaska Native) and asked to describe their race. While these variables were collected separately, the publicly available dataset provided one combined race/ethnicity variable with options of white, non-Hispanic; Black, non-Hispanic; American Indian/Alaskan Native, non-Hispanic; Asian/Native Hawaiian/other Pacific Islander, non-Hispanic; and Hispanic any race. Total combined household income in last 12 months was asked, with 21 categories ranging from <US$5000 to >US$200 000. Respondents were asked the category that best describes their sexual orientation (heterosexual (straight), gay or lesbian, bisexual, not sure). If 'not apparent', interviewers asked participants their sex (male, female), which we labelled as gender.

Our outcome of interest was a five-category indicator of self-reported health, recoded into a binary variable of excellent/very good or good/fair/poor. Self-reported health has been well established as a single-item measure of overall health and as a strong indicator for mortality.[3 4 7 10] We also examined several individual characteristics to highlight different ways of framing, understanding and modelling intersectionality. We used binary variables to simplify the interpretation of interactions, and to clearly show differences in results between the traditional non-intersectional analyses and two different types of interaction analyses. Race/ethnicity was combined, based on Bowleg's framework, and defined as white (non-Hispanic) or Black Indigenous People of Color (BIPOC) (any race/ethnicity, Black non-Hispanic, American Indian/Alaska Native non-Hispanic, Asian/Native Hawaiian/other Pacific Islander non-Hispanic or Hispanic any race).[2] We used survey variables for household size and household income to derive an indicator of whether the individual was above or below 138% of the federal poverty level, which is a threshold used by the Department of Health and Human Services to determine eligibility for expanded Medicaid coverage.[16] Sexual orientation was defined as gay/lesbian/bisexual/not sure (LGBQ+) or heterosexual/straight. Finally, we used the norm-based physical and mental disability scales to determine whether an individual had no disability or either/both physical and/or mental disabilities. The norm-based scales in NESARC-III were derived using the scoring methods described by Turner-Bowker *et al*.[17] Norm-based scores have a standardised range between 0 and 100 with a mean of 50. Higher scores indicate higher levels of physical and mental functioning, or vice versa, lower scores indicate more severe disability. For the purpose of illustrating interactions between categorical variables, we

Table 1 Multivariate logistic regression modelling self-reported health using approach 2, between-group comparisons, with a single 16-level categorical variable

16-level categorical variable						
R/E	Poverty	Disability	Orientation	aOR	95% CI	P value
White	Above	None	Heterosexual	Ref.		
White	Above	None	LGBQ+	0.90	0.71 to 1.13	0.36
White	Above	Yes	Heterosexual	0.12	0.10 to 0.13	<0.0001
White	Above	Yes	LGBQ+	0.13	0.08 to 0.19	<0.0001
White	Below	None	Heterosexual	0.52	0.45 to 0.59	<0.0001
White	Below	None	LGBQ+	0.27	0.14 to 0.48	<0.0001
White	Below	Yes	Heterosexual	0.06	0.05 to 0.07	<0.0001
White	Below	Yes	LGBQ+	0.06	0.03 to 0.12	<0.0001
BIPOC	Above	None	Heterosexual	0.58	0.54 to 0.63	<0.0001
BIPOC	Above	None	LGBQ+	0.53	0.40 to 0.70	<0.0001
BIPOC	Above	Yes	Heterosexual	0.11	0.09 to 0.12	<0.0001
BIPOC	Above	Yes	LGBQ+	0.10	0.06 to 0.17	<0.0001
BIPOC	Below	None	Heterosexual	0.35	0.32 to 0.40	<0.0001
BIPOC	Below	None	LGBQ+	0.39	0.25 to 0.61	<0.0001
BIPOC	Below	Yes	Heterosexual	0.05	0.04 to 0.06	<0.0001
BIPOC	Below	Yes	LGBQ+	0.11	0.06 to 0.20	<0.0001

Model included survey weights and strata using complex survey design procedures in SAS (V 9.4); adjusted for age group and gender.
aOR, adjusted OR; BIPOC, Black Indigenous People of Color.; LGBQ+, gay/lesbian/bisexual/not sure; R/E, race/ethnicity.

defined disability as any score less than 1 SD below the mean. We also adjusted our models for age group (18–29, 30–39, 40–49 or more than 50 years) and gender (male or female).

Analysis

Our decision on which intersectional analytical approaches to compare was informed by Else-Quest and Hyde's[18] comparison of techniques and reinforced by Guan *et al*'s systematic review in which the most popular methods of included intersectionality studies used an interaction term (64%, approach 3), an additive scale (51%, approach 1) and a multiplicative scale (40%, approach 2).[12 18]

Approach 1 analysis: non-intersectional basic multivariate regression

We described the distribution of each study variable, and used χ^2 tests of independence to check for bivariate associations between each variable and self-reported health. We used multivariate logistic regression to model self-reported health, including each of the four intersectional variables of interest and adjusting for age group and gender. We reported ORs, 95% CIs and p values for each focal variable.

Approach 2 analysis: intersectional multivariate regression with a single multicategorical predictor variable

We created a new, single categorical variable that represented every possible combination of our four binary variables, a between-group comparison. This strategy resulted in a predictor variable with 16 levels, with a heterosexual white individual above the poverty level with no disability as referent. We reported the distribution of each of the 16 possible variable levels and included a χ^2 test of independence to test for differences between levels of self-reported health. We included the new 16-level categorical variable in a multivariate logistic regression model and adjusted for age group and gender. We used output generated by the model to calculate the predicted probability of each subgroup reporting excellent or very good health, and plotted the probabilities in ascending order to help visualise the differences in effect size between variable levels. It is likely that some researchers may desire to evaluate associations using any one of 16 possible reference groups, where white, above poverty, no disability and heterosexual are not the preferred referent. Therefore, we also calculated every possible comparison between variable levels by alternating through each reference group, resulting in 120 unique between-group comparisons and derived from a single model.

Approach 3 analysis: intersectional multivariate regression with interactions

The final analytic approach included within-group testing of all possible two-way interactions among the four focal predictor variables of race/ethnicity, poverty status, disability status and sexual orientation. The interactions are designed to test the extent to which the association

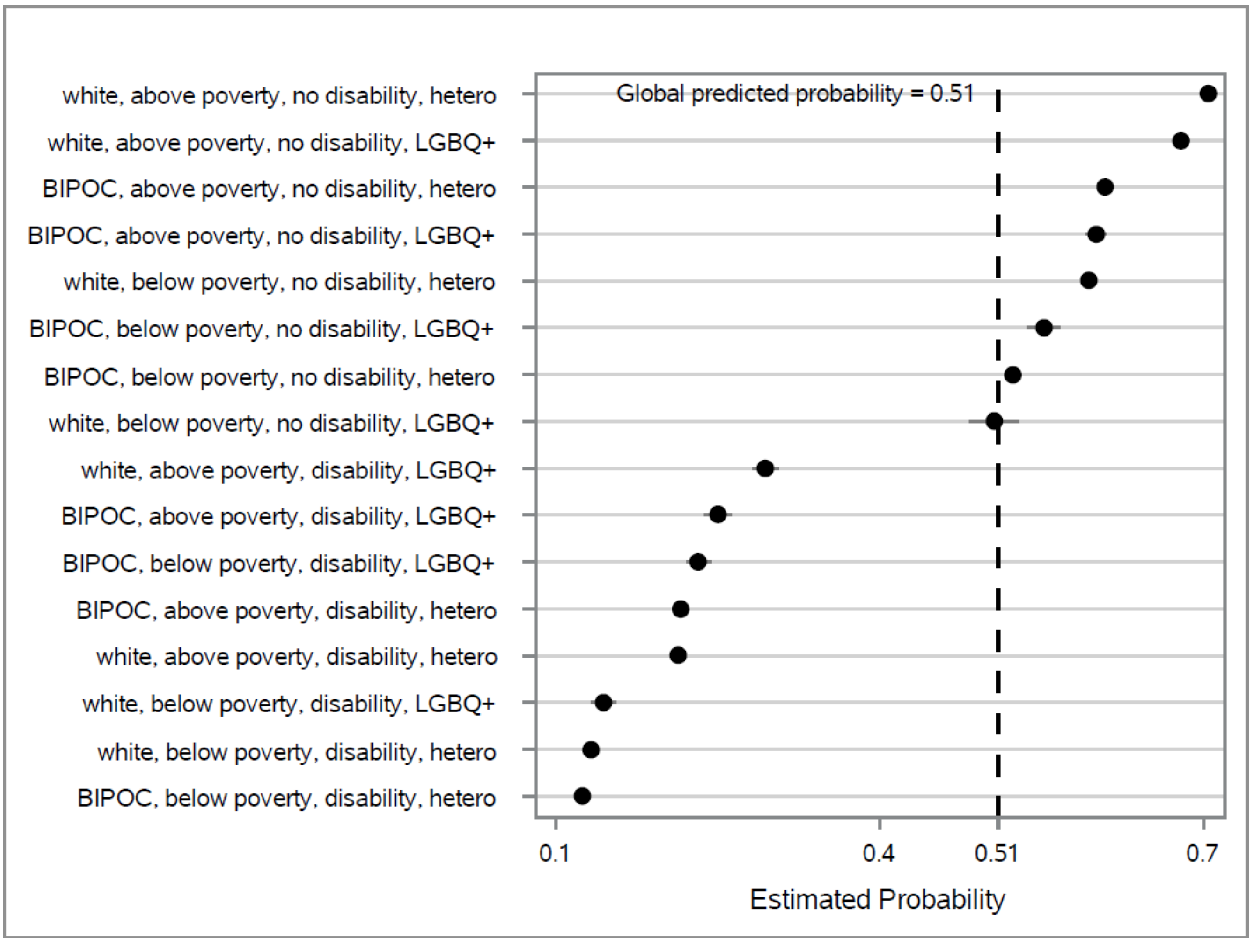

Figure 1 Predicted probability of reporting excellent or very good health. LGBQ+, gay/lesbian/bisexual/not sure. BIPOC, Black Indigenous People of Color.

between one variable and self-reported health varies by—or depends on—the value of a second variable. Within-group ORs were based on estimates of least square means. We used an SAS procedure designed to accommodate generalised linear models with a logit link.

Interactions are very common in social and behavioural health research and provide a valuable comparison to the intersectional approaches 1 and 2, above. Interactions are commonly conceptualised as 'moderation', 'effect modification', or 'conditional process analyses' and are useful as they add nuanced but important information that is different from effects identified using approaches 1 or 2. Interaction terms in regression equations generate statistical inference about the extent to which the effect of one variable (independent variable) on another (dependent variable) depends on the value of a third variable (moderator). Statistical inference derived from a test statistic and p value about a moderated effect is different from what one may achieve in assessing subgroup differences using our intersectional approach 2. In the latter, differences in effects or coefficients between groups can only be assessed qualitatively, whereas an interaction term will reveal whether the difference in effects across levels of a moderator is statistically significant.

For each of the three approaches tested, we also calculated the model-based predicted probabilities of excellent/very good health for each of the 16 combinations of intersectional characteristics in order to visualise important differences between each of the analytic approaches.

RESULTS

Approach 1 results: non-intersectional basic multivariate regression

Roughly half of the sample reported excellent or very good health (52%, n=18 876) (online supplemental table 1). The majority were white, non-Hispanic (66%, n=19 194), above the federal poverty level (82%, n=27 901), had no disability (75%, n=26 599), and heterosexual (96%, n=34 644). Several characteristics were associated with excellent or very good health in bivariate χ^2 tests, including white, non-Hispanic race/ethnicity (p<0.0001), above the federal poverty level (p<0.0001), no disability (p<0.0001), and heterosexual (p=0.01).

In the fully fitted model, BIPOC individuals were about one-third less likely to report excellent or very good health compared with white individuals (adjusted

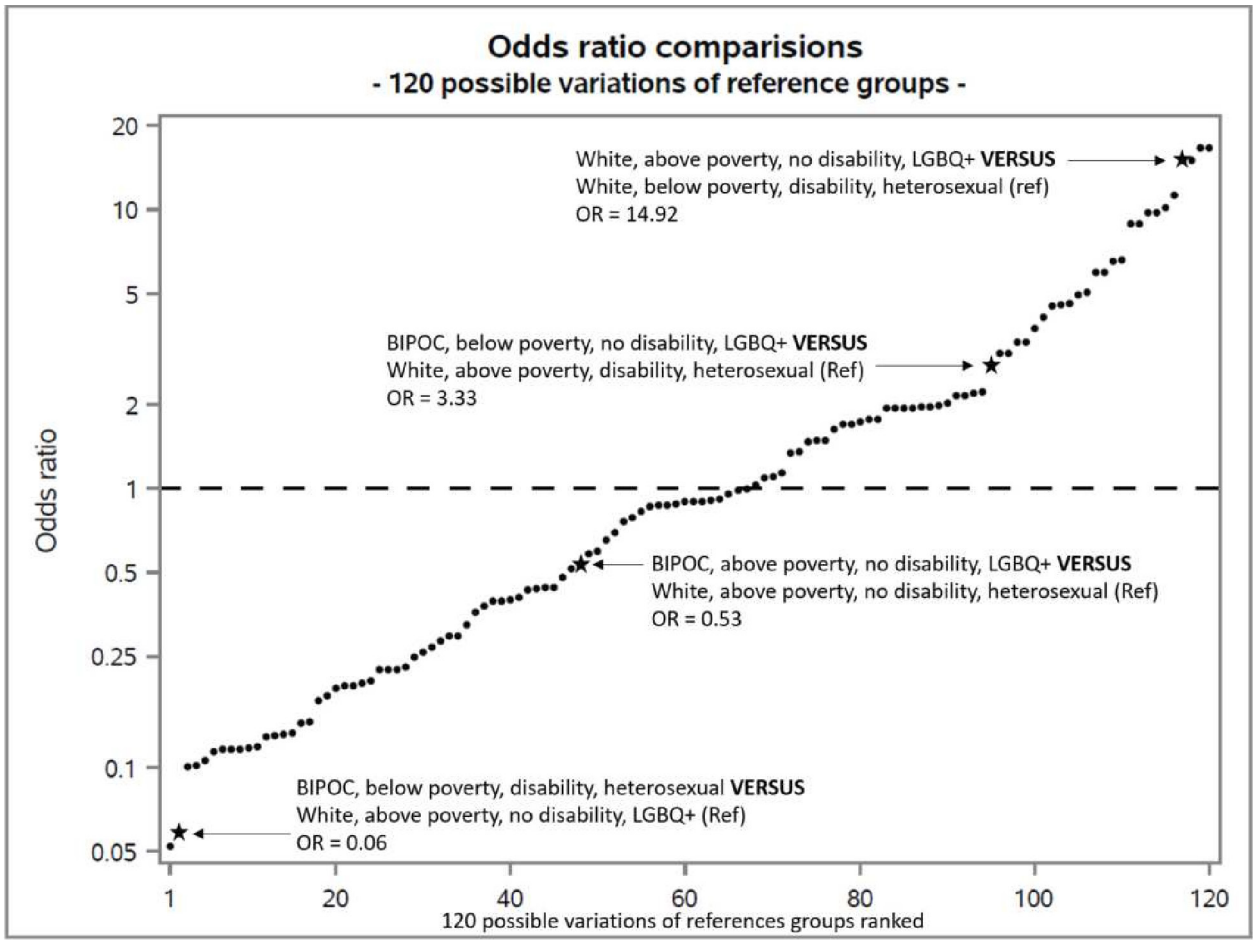

Figure 2 Comparisons of all possible combinations of reference groups for a single 16-level categorical intersectional variable. LGBQ+, gay/lesbian/bisexual/not sure. BIPOC, Black Indigenous People of Color.

OR (aOR)=0.65, 95% CI=0.61 to 0.69, p<0.0001) (online supplemental table 2). Those below the federal poverty level demonstrated nearly half the odds of reporting excellent or very good health, compared with those above the poverty level (aOR=0.55, 95% CI=0.51 to 0.59, p<0.0001). Compared with those with no disability, having any physical or mental disability was very strongly associated with lower odds of excellent or very good health (aOR=0.13, 95% CI=0.12 to 0.14, p<0.0001). We identified no statistically significant difference in the odds of excellent or very good health between heterosexual and LGBQ+ individuals (aOR=0.95, 95% CI=0.82 to 1.10, p=0.47).

Approach 2 results: intersectional multivariate regression with a single multicategorical predictor variable

Using the 16-level combined variable, the majority of the sample was white, above the federal poverty level, had no disability and was heterosexual (43%, n=11 925) (online supplemental table 3). The next largest groups included BIPOC, above the federal poverty level, no disability, and heterosexual (19%, n=8850) and white, above the federal poverty level, with a disability, and heterosexual (12%, n=3535). The smallest group represented was white, below the federal poverty level, no disability and LGBQ+ (0.23%, n=87). There was a significant bivariate association across the 16 categorical levels and between excellent/very good and good/fair/poor health statuses (p<0.0001).

In the fully fitted model, compared with individuals who were white, above the poverty level, had no disability and were heterosexual (referent), only those who were white, above the poverty level, had no disability and were LGBQ+ demonstrated no significant difference in the odds of reporting excellent/very good health (aOR=0.90, 95% CI=0.71 to 1.13, p=0.36) (table 1). Otherwise, all of the other remaining 14 categorical levels were significantly less likely than the referent to report excellent/very good health (p<0.0001 for all other levels). For the full sample, the predicted probability for reporting excellent/very good health was 51% (figure 1). Within each of the 16 groups, the probability of reporting excellent/very good health ranged from as high as 71% (among white, above poverty, no disability,and heterosexual) to as low as 12% (among BIPOC, below poverty, disability and heterosexual). Among the 16 possible groups, the top 8 groups all have no disability, indicating that disability is a key driver of poor health for all.

We also explored strategies to illustrate effect sizes for every possible variable level and cycling through referent

Table 2 Multivariate logistic regression modelling self-reported health using approach 3 with two-way interactions and within-group comparisons

Variables	aOR	95% CI	P value
Interactions			
Race/ethnicity as a moderator			
1. Comparisons within whites			
Below versus above poverty (ref.)	0.49	0.48 to 0.50	<0.0001
Disability versus no disability (ref.)	0.13	0.12 to 0.14	<0.0001
LGBQ+ versus heterosexual (ref.)	0.94	0.93 to 0.95	<0.0001
2. Comparisons within BIPOC, any race/ethnicity			
Below versus above poverty (ref.)	0.59	0.58 to 0.60	<0.0001
Disability versus no disability (ref.)	0.20	0.19 to 0.21	<0.0001
LGBQ+ versus heterosexual (ref.)	1.13	1.11 to 1.15	<0.0001
Poverty as a moderator			
3. Comparisons within those who are above federal poverty level			
BIPOC versus white (ref.)	0.77	0.75 to 0.79	<0.0001
Disability versus no disability (ref.)	0.16	0.15 to 0.17	<0.0001
LGBQ+ versus heterosexual (ref.)	1.04	1.03 to 1.05	<0.0001
4. Comparisons within those who are below federal poverty level			
BIPOC versus white (ref.)	0.92	0.91 to 0.93	<0.0001
Disability versus no disability (ref.)	0.15	0.14 to 0.16	<0.0001
LGBQ+ versus heterosexual (ref.)	1.03	1.02 to 1.04	<0.0001
Disability as a moderator			
5. Comparisons within those with no disability			
BIPOC versus white (ref.)	0.69	0.68 to 0.70	<0.0001
Below versus above poverty (ref.)	0.55	0.54 to 0.56	<0.0001
LGBQ+ versus heterosexual (ref.)	0.89	0.88 to 0.90	<0.0001
6. Comparisons within those with any disability			
BIPOC versus white (ref.)	1.02	1.01 to 1.03	<0.0001
Below versus above poverty (ref.)	0.52	0.51 to 0.53	<0.0001
LGBQ+ versus heterosexual (ref.)	1.20	1.19 to 1.21	<0.0001
Sexual orientation as a moderator			
7. Comparisons within heterosexual/straight individuals			
BIPOC versus white (ref.)	0.77	0.76 to 0.78	<0.0001
Below versus above poverty (ref.)	0.54	0.53 to 0.55	<0.0001
Disability versus no disability (ref.)	0.13	0.12 to 0.14	<0.0001
8. Comparisons within gay/lesbian/bisexual individuals			
BIPOC versus white (ref.)	0.92	0.91 to 0.93	<0.0001
Below versus above poverty (ref.)	0.53	0.52 to 0.54	<0.0001
Disability versus no disability (ref.)	0.19	0.18 to 0.20	<0.0001

Model included survey weights and strata using complex survey design procedures in SAS (V 9.4); adjusted for age group and gender.
aOR, adjusted OR; BIPOC, Black Indigenous People of Color.; LGBQ+, gay/lesbian/bisexual/not sure.

group comparisons (figure 2). We identified a range of referent group combinations that were highly predictive of excellent/very good health. For example, compared with BIPOC individuals who were below poverty, had a disability and were heterosexual (referent), BIPOC individuals who were above poverty, did not have a disability and were LGBQ+ demonstrated over 10 times greater odds of reporting excellent or very good health (OR=10.16, 95% CI=10.12 to 10.20).

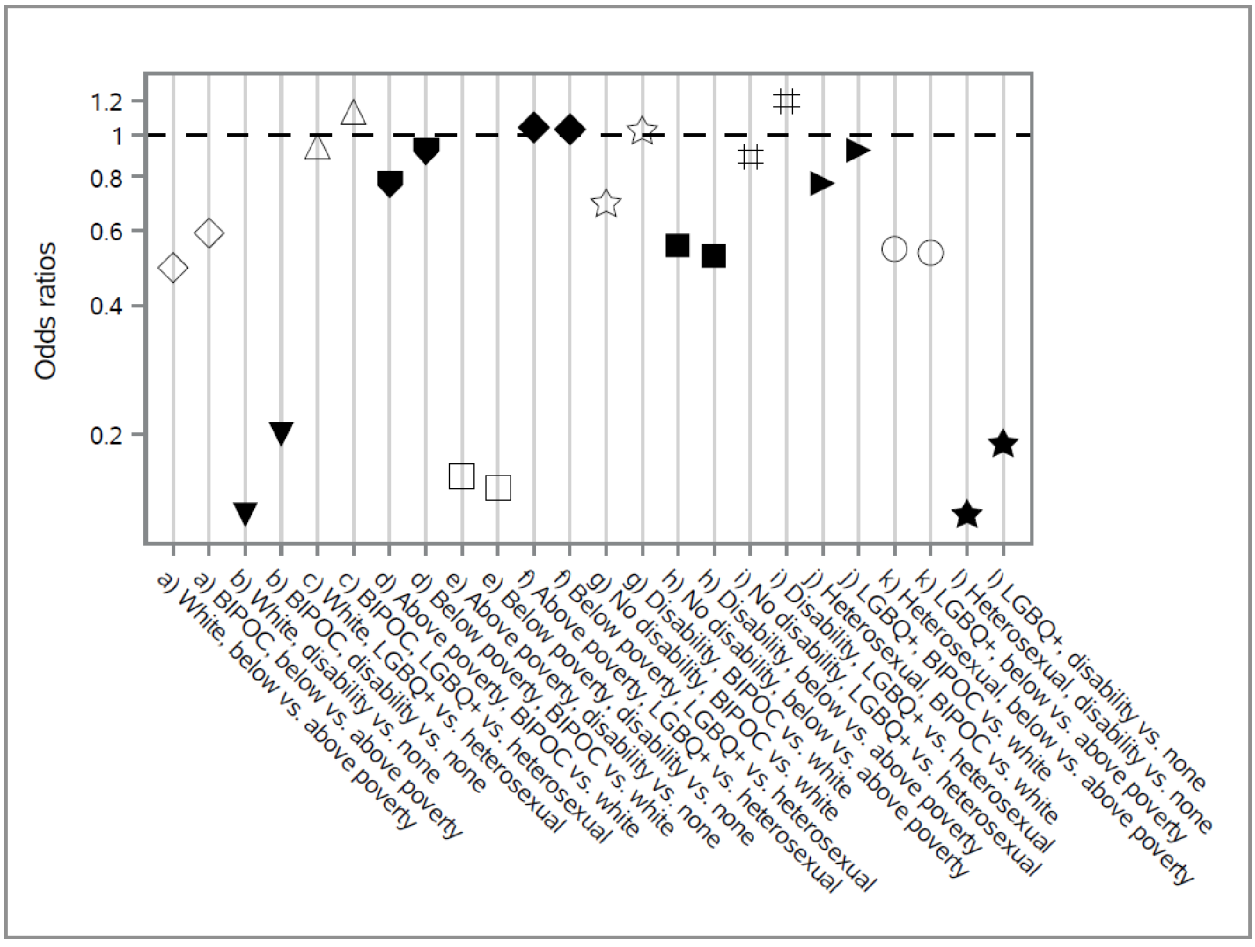

Figure 3 Plotted ORs, using approach 3 and within-group effect size comparisons. LGBQ+, gay/lesbian/bisexual/not sure. BIPOC, Black Indigenous People of Color.

Approach 3 results: intersectional multivariate regression with two-way interactions

The demographic distribution of study variables is the same as analysis approach 1 (online supplemental table 1). Results from the interaction model and within-group associations for each focal predictor variable are presented (table 2). There were three notable occasions when the direction of the effect flipped between subgroups. First, compared with heterosexual individuals, LGBQ+ individuals had lower odds of reporting better health among whites (aOR=0.94, 95% CI=0.93 to 0.95) but higher odds of reporting better health among BIPOC individuals (aOR=1.13, 95% CI=1.11 to 1.15). Second, compared with white individuals, BIPOC individuals had lower odds of reporting better health among those without a disability (aOR=0.69, 95% CI=0.68 to 0.70) but higher odds of reporting better health among those with a disability (aOR=1.02, 95% CI=1.01 to 1.03). Third, compared with heterosexual individuals, LGBQ+ individuals had lower odds of reporting better health among those without a disability (aOR=0.89, 95% CI=0.88 to 0.90) but higher odds of reporting better health among those with a disability (aOR=1.20, 95% CI=1.19 to 1.21). Each of these three findings is also evident in our illustration of differences in effect sizes within groups (figure 3). Changes in the direction of effect (from positive to negative) are indicated by any pair of markers on opposite sides of the OR value of one, which is denoted by a dashed line on the figure.

Predicted probability comparisons

To compare differences in model function, we estimated the model-based predicted probability of excellent/very good health for each of the 16 combinations of intersectional characteristics, as well as the descriptive percentage of excellent/very good health for each group (table 3). Several subgroups demonstrated a larger range of predicted probabilities among the three model approaches. For example, the predicted probabilities for the three models among white LGBQ+ individuals below the poverty threshold and with a disability were 16.3%, 14.4% and 15.4%, respectively. In comparison, the predicted probabilities for the three models among BIPOC LGBQ+ individuals above the poverty threshold with a disability showed much more variation, including 19.6%, 25.0% and 28.9%, respectively—nearly a 10 percentage point difference between approaches 1 and 3. Differences in predicted probability estimates between the three approaches highlights important distinctions between the model functions.

Table 3 Comparison of predicted probabilities between three statistical approaches: (1) non-intersectional basic multivariate regression, (2) intersectional multivariate regression with a single multicategorical predictor variable and (3) intersectional multivariate regression with two-way interactions

Intersectionality variables				Excellent or very good health (%)			
				Descriptive percentages	Predicted probabilities for three analysis approaches		
R/E	Poverty	Disability	Orientation		1	2	3
White	Above	None	Heterosexual	70.6	70.1	70.4	70.8
White	Above	None	LGBQ+	69.5	69.9	67.9	67.5
White	Above	Yes	Heterosexual	21.1	22.7	21.3	21.4
White	Above	Yes	LGBQ+	26.0	25.6	29.4	26.9
White	Below	None	Heterosexual	60.3	60.0	59.3	59.3
White	Below	None	LGBQ+	45.6	59.9	50.5	55.4
White	Below	Yes	Heterosexual	12.5	14.4	13.2	12.0
White	Below	Yes	LGBQ+	15.2	16.3	14.4	15.4
BIPOC	Above	None	Heterosexual	61.6	63.4	60.9	61.8
BIPOC	Above	None	LGBQ+	62.3	65.0	60.0	64.1
BIPOC	Above	Yes	Heterosexual	21.1	17.6	21.5	20.5
BIPOC	Above	Yes	LGBQ+	24.1	19.6	25.0	28.9
BIPOC	Below	None	Heterosexual	52.9	51.9	52.3	52.7
BIPOC	Below	None	LGBQ+	58.0	53.6	55.2	54.8
BIPOC	Below	Yes	Heterosexual	11.8	10.6	12.5	13.0
BIPOC	Below	Yes	LGBQ+	27.8	12.5	23.2	19.8

BIPOC, Black Indigenous People of Color.; LGBQ+, gay/lesbian/bisexual/not sure; R/E, race/ethnicity.

DISCUSSION

Each approach offers unique insight about the relationship between individual characteristics and self-reported health. Approach 1 (non-intersectional basic multivariate regression) is a classic strategy used to parse out the confounding effect of multiple variables in a model. We interpreted the influence of one variable on the outcome by holding the values of all other variables constant, allowing for the interpretation of an adjusted effect. However, this approach is non-intersectional and does not consider how each variable may intersect with another in any other way than adjusting for confounding. Main effects models have historically been used for social determinants of health research, and in the more recent application of intersectionality to quantitative research methods, some have included main effects models as representative of intersectionality research *if* the discussion includes an intersectional interpretation. However, we agree that the additive assumption underlying main effects models does not quantify the impact of the lived experience at the intersection of different marginalised identities that is greater than the sum of the parts.[11 18 19] We have therefore used approach 1 to illustrate the baseline non-intersectional results, for comparison to approaches 2 and 3, which resulted in more specific opportunities to compare the experiences of marginalised groups in relation to self-reported health.

Approach 2 (single, 16-level categorical predictor) allows for a bit more flexibility and creativity in a logistic regression problem. Direct comparisons of predicted probabilities among each of the 16 levels make interpretation of the 'risk' of poor health easier to interpret when plotted on a graph. Rotating through all reference groups is likely not necessary for most research questions, but the value in demonstrating this strategy is to show what is possible using a single intersectional variable. This between-group strategy may be useful for studies investigating multiple lived experiences and interested in prioritising specific communities for public health programming. It is important that study designs and research questions are clearly stated at the outset of such analyses, as the total number of possible reference groups and comparisons increases substantially with each additional variable.

Approach 3 used interaction terms to model the extent that the relationship between each predictor and self-reported health depended on the value of a third predictor variable, a methodology that allows social positions to change at a variety of intersections.[20] Isolating these within-group effects can be very valuable when determining strategic public health intervention entry points and prioritising the most oppressed populations.[18] By directly comparing effect sizes within groups, researchers are able to discern when—or under what

conditions—certain characteristic combinations may facilitate or inhibit improved health. This approach gets away from a 'one-size-fits-all' mentality, and instead stresses the importance of carefully considering differences in effects within groups. The current study used dichotomous categorical variables to ease interpretation of the interactions and the results. However, interactions with continuous variables are possible with linear models, and computing software programmes such as SAS are able to accommodate a wide range of interactions with different variable types, varying outcome distributions, and many different underlying assumptions about the statistical model and study design.

The limitations of this study include the use of older data and smaller sample sizes of less than 1% in seven of the 16-level categorical predictors used in approach 2. As a newer version of NESARC-III has not yet been collected, coauthors had significant experience analysing this publicly available dataset,[21–25] and variables were collected to represent the four categories of race/ethnicity, poverty level, sexual orientation and disability status, we chose familiarity with the data over a more recent publicly available dataset. These analyses include individual-level variables based on self-identified identity, and do not include systems-level variables, an important extension of intersectionality research.[26] While the majority of intersectionality research tests sex/gender and/or age/generation,[20 27] few compare methodologies and apply four different marginalised identities while also addressing the call for using intersectional frameworks in public health.[2] The large sample size allows for the significant findings in the interpretation of two-way interactions and within-group comparisons that exist, highlighting the important contributions of disability status, sexual orientation and race/ethnicity in self-reported health.[11]

Intersectionality impacts the lives of US residents through lived experience. Public health research needs to account for this complexity in analyses and interpret the findings within the structural power inequities that underlie access to public health prevention, screening, and treatment. Our results, indicating the worst self-reported health status of BIPOC, heterosexual individuals with disabilities and below poverty, are supported by other intersectional life-course research which identified black women experiencing increased rates of disability through their lives, potentially due to the lived experiences of discrimination and racism, plus stressful family caretaking roles.[28] This finding is also supported by evidence that interventions meant to improve health outcomes in marginalised populations tend to be most effective and beneficial to those with more power in-group, and those with multiple marginalised identities benefit the least.[4 5 10] Disability and ability status are often not included in studies of intersectionality and health inequities,[8 12] but our results show that disability is strongly associated with poorer self-reported health at intersections with all three of the other identities in this study. Ability status needs to be included in future studies on intersectionality and health inequities. Along the life-course, different intersectional identities contribute to varying access to prevention, diagnosis and treatment of acute and chronic medical complications.[28]

This research contributes to the methodological discussion by contrasting different quantitative analytic methodologies to account for multiple possible identities of race/ethnicity, sexual orientation, income, and disability status. Using different, intersectional quantitative methods may offer a more precise and nuanced understanding of the existence of health inequalities and a more comprehensive account of the context in which these inequalities occur.[9 10] Cognizance of who has the power at individual, interpersonal, and societal levels to control their health outcomes will enable us to design public health interventions and policies that are accessible and effective for those with the least power to improve their health outcomes, benefitting those with less power as well as those with greater power in society.

Using intersectional theory to improve our understanding of how intersectional identities relate to health inequities may help us focus on dynamics of power and wealth and move away from attributing risk to specific individuals or groups.[10] While there is a concern that researchers will continue to use these quantitative tools to attribute risk to specific individuals or groups, we stress the qualitative roots of intersectionality theory and the inherent call for the examination of the social power context in which health inequities occur. It is only through the measurement of compounding intersectional experiences within healthcare that programme planning can address multiple needs simultaneously.

Contributors BAL: Conceptualisation, writing—original draft, supervision, project administration, funding acquisition, guarantor. GCP: Methodology, software, formal analysis, data curation, writing—original draft, visualisation. SBR-M: Writing—original draft. RC: Writing—original draft.

Funding The project described in this publication was supported by the University of Rochester's Department of Obstetrics and Gynecology and CTSA award number UL1 TR002001 from the National Center for Advancing Translational Sciences of the National Institutes of Health. The content is solely the responsibility of the authors and does not necessarily represent the official views of the University of Rochester, Department of Obstetrics and Gynecology, or National Institutes of Health.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The University of Rochester Research Subjects Review Board determined the study was not human research (STUDY00006522).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. Access to NESARC-III was granted to the study team by the National Institute on Alcohol Abuse and Alcoholism.

terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

ORCID iD

Brooke A Levandowski http://orcid.org/0000-0003-3716-3818

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