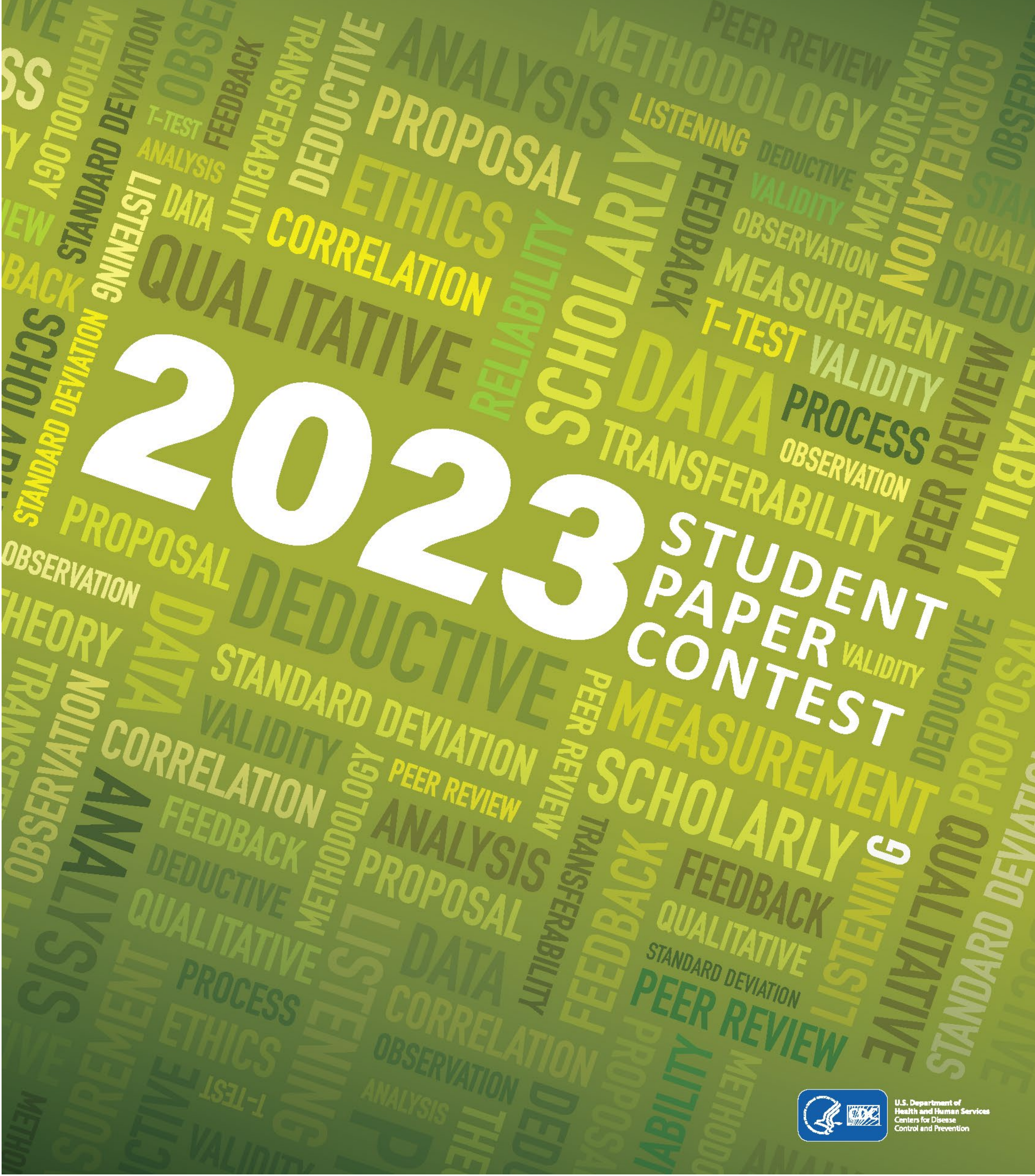
PREVENTING CHRONIC DISEASE

PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY



2023 STUDENT PAPER CONTEST

U.S. Department of
Health and Human Services
Centers for Disease
Control and Prevention

A Word From the Editor in Chief

The Preventing Chronic Disease (PCD) Student Paper Contest continues to be a well-received annual scientific writing opportunity for students and their faculty mentors around the world. PCD celebrates all students who decide to submit a paper for consideration regardless of whether it is accepted for publication or not. We believe students who participate gain valuable experience of the publication process that will contribute to their future career success. It gives students the opportunity to serve as a corresponding and first author, engage in the peer-review process, and interact with a well-respected journal. Faculty mentors also play a tremendous role in helping to shape the education and training of students, and PCD would like to acknowledge the faculty members who provided many hours of support to their students.

This year's collection of student papers addresses a range of topics that include views about COVID-19 racial disparities in morbidity and mortality among residents; effects of shared decision-making on emergency department use among people with high blood pressure; the contribution of physical activity disparities to inequitable health-related quality of life among Blacks with knee osteoarthritis; dynamic patterns and modeling of COVID-19 early transmission; barriers and preferences of physical activity in a national sample of rural men ; the association between self-reported lack of access to a neighborhood park and high blood pressure; and the impact of geography and rurality in perceptions of health status in the United States.

PCD is pleased to announce winners in the master's and doctoral degree categories. PCD congratulates Camille Kroll in the master's degree category for her paper, "'I Don't Really Pay Attention to the Racial Stuff Very Much': An Exploratory Qualitative Analysis of St. Louis Residents' Explanations of COVID-19's Racial Disparities"; and R. Aver Yakubu in the doctoral degree category for the paper, "Shared Decision-Making and Emergency Department Use Among People With High Blood Pressure." Congratulations to this year's winners! It is important to point out that the paper led by Camille Kroll is the first qualitative research paper selected as a winner in any category. There were no winners identified for selection in the high school, undergraduate, or postdoctoral categories.

PCD looks forward to receiving student papers in response to its 2024 Student Paper Contest call for papers. For more information on eligibility requirements, tips on submitting a quality paper, and the journal manuscript review process, visit our **Announcements page**. Interested student authors are also encouraged to visit the **Author's Corner** section of PCD's website for important information on what to avoid when developing the manuscript, tables, and figures. Manuscripts must be received electronically no later than 5:00 PM EST on Monday, March 25, 2024.

Leonard Jack, Jr, PhD, MSc
Editor in Chief, Preventing Chronic Disease

About the Journal

Preventing Chronic Disease (PCD) is a peer-reviewed public health journal sponsored by the Centers for Disease Control and Prevention and authored by experts worldwide. PCD was established in 2004 by the National Center for Chronic Disease Prevention and Health Promotion with a mission to promote dialogue among researchers, practitioners, and policy makers worldwide on the integration and application of research findings and practical experience to improve population health.

PCD's vision is to serve as an influential journal in the dissemination of proven and promising peer-reviewed public health findings, innovations, and practices with editorial content respected for its integrity and relevance to chronic disease prevention.

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PREVENTING CHRONIC DISEASE
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ORIGINAL RESEARCH

Shared Decision-Making and Emergency Department Use Among People With High Blood Pressure

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PEER REVIEWED

Summary

What is already known on this topic?

Several studies have assessed the relationship among chronic disease, shared decision-making, and health care use, but information is limited on the relationship among high blood pressure, shared decision-making, and use of emergency department services.

What is added by this report?

Findings from this report provide insight on how predisposing, enabling, and need factors based on the Andersen model contribute to shared decision-making and emergency department use.

What are the implications for public health practice?

Future studies can expand on the perceived use of shared decision-making among people with chronic disease to improve outcomes and types of health care services used.

Abstract

Introduction

Forty-seven percent of all adults in the US have a diagnosis of high blood pressure. Among all US emergency department (ED) users, an estimated 45% have high blood pressure. The success of high blood pressure interventions in reducing ED visits is partially predicated on patients' adherence to treatment plans. One method for promoting adherence to treatment plans is shared decision-making between patients and medical providers.

Methods

We conducted a cross-sectional observational study using 2015–2019 Medical Expenditure Panel Survey data. We used studies on shared decision-making as a guide to create a predictor variable for shared decision-making. We determined covariates according to the Andersen Behavioral Model of Health Services Use. ED use was the outcome variable. We used cross tabulation to compare covariates of ED use and multivariable logistical regression to assess the association between shared decision-making and ED use. Our sample size was 30,407 adults.

Results

Less than half (39.3%) of respondents reported a high level of shared decision-making; 23.3% had 1 or more ED visits. In the unadjusted model, respondents who reported a high level of shared decision-making were 20% less likely than those with a low level of shared decision-making to report 1 or more ED visits (odds ratio [OR], 0.80; 95% CI, 0.75–0.86; $P < .001$). After adjusting for covariates, a high level of shared decision-making was still associated with lower odds of ED use (OR, 0.86; 95% CI, 0.76–0.97; $P = .01$).

Conclusion

Shared decision-making may be an effective method for reducing ED use among patients with high blood pressure.

Introduction

Heart disease is the leading cause of death in the US and worldwide (1). In the US, 47% of all adults have been diagnosed with one of the major risk factors for heart disease, high blood pressure (2). High blood pressure is often called the silent killer because many people are asymptomatic and unaware of their condition (3). Among all adults diagnosed with high blood pressure, only 1 in 4 have their high blood pressure under control (able to lower blood pressure with medication) (2). Uncontrolled high blood pressure is associated with increased risk for preventable emergency department (ED) visits. From 2006 to 2012, in the most recent analysis available on ED use and high blood pressure, ED visits caused by high blood pressure increased by 4% each year (4). Among all ED users in the US, an estimated 45% have high blood pressure (5). The COVID-19 pandemic further exacerbated these trends, with systolic blood pressure increasing on average by 1.79 mm Hg and diastolic blood pressure increasing on average by 1.30 mm Hg from the prepandemic period (August 2018 through January 2020) to the pandemic period (April 2020 through November 2020) (6). Experts have recommended evidence-based interventions for reducing high blood pressure as a way to save 100 million lives worldwide by 2040 (7). Reductions in the use of EDs for managing high blood pressure can serve as a proxy for the successful implementation of interventions to reduce high blood pressure. However, the success of high blood pressure interventions and reducing ED visits is partially predicated on patients adhering to treatment plans. One method for promoting adherence to treatment plans is a positive relationship between a patient and a clinician (8).

Positive patient–clinician relationships improve patient satisfaction, medication adherence, and successful development of treatment plans (9–12). A component of patient–provider relationships is shared decision-making. Shared decision-making is a collaboration in which treatment options are explained by the clinician and the patient provides feedback on what they prefer (13). Shared decision-making is achieved when patients are empowered to be involved in all aspects of health care discussions and decision-making (14). Several studies have assessed the relationship among chronic disease, shared decision-making, and health care use (10,15,16). However, knowledge is limited on the relationship among high blood pressure, shared decision-making, and ED use (4,7,10,17).

Previous studies indicate that the Andersen Behavioral Model of Health Services Use, often referred to as the Andersen model, is an appropriate framework for assessing behaviors contributing to health care use and shared decision-making (18,19). The Andersen model has various iterations, but the fundamental components are predisposing factors, enabling factors, and need factors (18,19). Predisposing factors are individual characteristics that would influence a person toward use of health care; examples are age, education, race, and ethnicity. Enabling factors are external resources that create the ability to use care; examples are transportation, health insurance, and the ability to pay for health care. Having access to a clinician who engages in shared decision-making could also be considered an enabling factor. Need factors are the individual's or clinician's perception of whether the individual needs care. According to the Andersen model, people are more inclined to seek health care when they perceive a greater need for care, have access to enabling resources, and possess predisposing factors that motivate them to seek care. Studies on shared decision-making and the Andersen model posit that shared decision-making improves equity in care and supports positive behavior in the use of health care services, such as seeking preventive and primary care services rather than ED services to manage chronic conditions (20). This model proves valuable in comprehending the intricate interactions among these factors, thereby aiding in the analysis of patterns in health care use across diverse populations.

The objective of this study was to assess the relationship between shared decision-making and ED use among adults with a diagnosis of high blood pressure. The Andersen model provided a framework for our study to explain how ED use is influenced by these predisposing factors, enabling factors, and need factors. We hypothesized that a high level of shared decision-making would be significantly associated with lower levels of ED use.

Methods

Study design

We conducted a cross-sectional observational study using 2015–2019 Medical Expenditure Panel Survey (MEPS) data, a population-based survey managed by the Agency for Healthcare Research and Quality (21). MEPS collects data by using a set of large-scale surveys of families and individuals, their clinician, and employers across the US. Collectively, these data offer a nationally representative sample of the US population. Our study used data from the household component, which draws from a subsample of households that participated in the previous year's National Health Interview Survey (administered by the National Center for Health Statistics). The panel design includes several rounds of interviews that cover 2 calendar years to assess changes in health status, income, employment, and use of services. Inclusion criteria for our study were being aged 18 years or older (n = 118,839), having ever been diagnosed with high blood pressure (n = 40,605), and having attended at least 1 physician's visit in the previous year (n = 51,992); 30,407 respondents met all 3 criteria and were included in our final analytic sample. Respondents with missing data for any of the 3 inclusion criteria were excluded from the final analytic sample. The Saint Louis University Institutional Review Board (IRB) determined that this study was exempt from IRB review.

Variables

Predictor variable: shared decision-making

On the basis of previous SDM-related studies (10,15), we developed a predictor variable for SDM by averaging 7 MEPS questions into a single composite score. The 7 questions were as follows:

- If there were a choice between treatments, how often would your medical provider ask you to help make the decision?
- Does a medical person at your usual source of care present and explain all options to you?
- Thinking about the types of medical, traditional, and alternative treatments you are happy with, how often does your medical provider show respect for these treatments?
- In the last 12 months, how often did your doctors or other health providers listen carefully to you?
- In the last 12 months, how often did your doctors or other health providers explain things in a way that you could understand?
- In the last 12 months, how often did your doctors or other health providers show respect for what you had to say?
- In the last 12 months, how often did your doctors or other health providers spend enough time with you?

Six of the shared decision-making questions were on a 4-point Likert scale ranging from 1 (never) to 4 (always). The remaining shared decision-making question (Does a medical person at your usual source of care present and explain all options to you?) had a yes/no response. We recoded this response as 1 (no) or 4 (yes). We recoded the mean values of the shared decision-making composite scores to a binary variable: low level of shared decision-making (mean summary score <3.9) and a high level of shared decision-making (mean summary score ≥3.9). This method was successfully tested for validity by Lindly et al (22).

Outcome variable: ED use

We used a single MEPS item for number of ED visits to create a variable for ED use. We recoded this variable as a binary variable: 1 or more ED visits versus 0 ED visits.

Covariates

We determined covariates on the basis of applicable predisposing, enabling, and need factors of the Andersen model available in the MEPS data set. Predisposing factors were age, sex, race and ethnicity, geographic region, highest educational degree earned, body mass index (BMI), and personal belief about seeing a physician. For this last item, we used responses to the MEPS question on respondents believing they can “overcome ills without medical help,” which we categorized as “uncertain or disagree” or “agree.” Enabling factors were income, based on the poverty category variable in MEPS (high [>400% poverty line]), middle [200%–400% poverty line], and low [<200% poverty line]), travel time to a doctor’s appointment, and health insurance (any private, public only, uninsured). For need factors, we considered only 1 variable to be applicable: self-perceived general health status. All covariates were categorical variables.

Statistical analysis

We used Stata version 14 MP (StataCorp LLC) to conduct all statistical analyses. We used appropriate sample weights to account for the complex survey design and produce nationally representative prevalence estimates. A descriptive overview of the sample included counts and percentages. We used χ^2 tests to assess significant relationships in cross tabulations between each variable and the outcome (ED use). We used binary logistic regression to assess associations between shared decision-making and ED use with covariates. Significance was set at $P \leq .05$.

Results

Of the final sample, less than half (39.3%) of respondents reported a high level of shared decision-making; 23.3% had 1 or more ED visits (Table 1). Most patients were aged 40 years or older (40–64 y, 46.2%; ≥65 y, 44.3%). By sex, we found an almost even distribution of men (49.3%) and women (50.7%). Most (68.7%) respondents were White only. The highest educational degree earned among most (54.7%) of respondents was a high school diploma or GED; 79.9% were classified as obese based on BMI, 42.5% had a high income, 63.4% had private insurance, and most considered themselves to have good (39.9%) or very good (28.4%) health status.

Shared decision-making and ED use

The independent variable and all covariates were significantly associated with ED use (Table 2). Among the Asian-only group, 11.5% reported 1 or more ED visits; 20% or more of all other racial and ethnic groups reported 1 or more ED visits. In unadjusted models of the association between shared decision-making and ED use, respondents who reported a high level of shared decision-making were 20% less likely than respondents who reported a low level of shared decision-making to report 1 or more ED visits (OR, 0.80; 95% CI, 0.75–0.86; $P < .001$) (Table 3). After adjusting for covariates in the model, a high level of shared decision-making was still associated with lower odds of ED use: respondents with a high level of shared decision-making were 14% less likely to report 1 or more ED visits (OR, 0.86; 95% CI, 0.76–0.97; $P = .01$).

Andersen model covariates and ED use

The highest prevalence of having 1 or more ED visits occurred among respondents who had no educational degree (30.1%), public-only insurance (30.8%), or low income (30.7%). The percentage of respondents who had 1 or more ED visits was higher among respondents who disagreed or were uncertain they could overcome ills without medical help than among respondents who agreed they could overcome ills on their own (24.0% vs 19.3%) (Table 2).

Among predisposing factors, several categories of age, sex, and race and ethnicity were significantly associated with having 1 or more ED visits (Table 3). The odds of having 1 or more ED visits were 24% lower among respondents aged 40 to 64 years than among respondents 18 to 39 years (OR, 0.76; 95% CI, 0.62–0.93; *P* = .007). Women had a 26% higher likelihood of ED use than men (OR, 1.26; 95% CI, 1.11–1.43; *P* <.001). Compared with the White-only group, the Asian-only group had 58% lower odds (OR, 0.42; 95% CI, 0.29–0.60; *P* <.001) and the Hispanic group had 19% lower odds (OR, 0.81; 95% CI, 0.66–0.99; *P* = .04) of ED use. The odds of ED use were similar for the Black and White groups. The following enabling factors were significantly associated with ED use: low income, 31 to 60 minutes of travel time to a doctor's appointment, and public-only insurance. Respondents with low income were 35% more likely than respondents with high income to use the ED (OR, 1.35; 95% CI, 1.16–1.58; *P* <.001). Having a longer travel time to doctor's appointment (31–60 min vs <15 min) was also associated with higher odds of ED use (OR, 1.27; 95% CI, 1.06–1.53; *P* = .01). Respondents with public-only insurance were 22% more likely than respondents with private insurance to use the ED (OR, 1.22; 95% CI, 1.06–1.40; *P* = .004). For self-perceived health status, respondents with poor health status were 5.44 times more likely than respondents with excellent self-perceived health status to have a high level of shared decision-making (OR, 5.44; 95% CI, 3.78–7.83; *P* = <.001).

Discussion

In our study, we used the Andersen model as a framework to assess the relationship between shared decision-making and ED use among patients with a high blood pressure diagnosis. Like other related studies, our study showed that less than half of patients reported a high level of shared decision-making, yet a high level of shared decision-making was associated with lower odds of ED use (16,22). Female sex and having low income, public-only insurance, or poor perceived health status were associated with higher odds of ED use.

We found several predisposing factors that contributed to increased ED use and differences in perceived shared decision-making. For example, among those who reported a high level of shared decision-making, women had higher odds than men of ED use. Findings in other studies on sex and ED use varied in terms of which sex had greater rates of ED use. In a study of women and men with multiple chronic diseases, men had higher odds of ED use (23). However, in a study assessing the ED experiences of Medicare beneficiaries, women reported a more positive experience than men in interacting with staff and receiving timely care, but they reported worse experiences than men in getting the type of care they felt they needed (24). Further studies on the relationship between sex or gender and relationship building with clinicians will provide more insight into improving shared decision-making and influencing health care use. Many studies on age, shared decision-making, and ED use in the past 10 years focused on adults aged 65 or older (25,26). Our findings showed that adults aged 18 to 39 years used the ED more than other age groups, suggesting the need for more studies assessing ED use across multiple age ranges. Future studies should assess the parameters of shared decision-making among various age groups and how beliefs or perceptions evolve.

Another interesting finding in our study was that, among those who reported a high level of shared decision-making, Hispanic-only survey respondents had lower odds of ED use than White-only survey respondents. The Hispanic-only group, overall, used the ED less than all other racial and ethnic groups in our study, with the exception of the Asian group. This finding is consistent with a scoping review study on Hispanic health that showed Hispanic adults are less likely to have visited a health care provider than all other racial or ethnic groups, possibly because of social and economic disparities, non–US-born or undocumented status, and mistrust of the health care system (27).

Among enabling factors, having public-only insurance, compared with private insurance, increased the likelihood of ED use. These findings align with other findings on insurance status and health care use. Common characteristics of Medicaid beneficiaries are more comorbidities and lower income, which are risk factors for higher rates of ED use (28). Although having insurance helps with access, Medicaid beneficiaries still experience barriers to care, such as difficulty finding medical providers that accept their insurance and lacking access to the same primary care provider over time to build a relationship and a continuous health improvement plan (28,29). Moreover, because Medicare beneficiaries are predominantly older and have more chronic diseases than non-Medicare beneficiaries, a higher rate of health care use is expected (30). Studies on innovative methodologies to improve shared decision-making among public insurance beneficiaries is needed and would be a benefit both for patients and health systems because of the possibility of further decreasing ED use.

Not surprisingly, respondents with poor self-perception of general health status, the single need factor examined in our study, had the highest rates of ED use (48.2%), while those with excellent perceptions of health status had the lowest rates of ED use (11.1%).

Additionally, a high level of shared decision-making and the odds of ED use were highest among those with poor self-perception. A study on shared decision-making and medication adherence, by Milky and Thomas (10), also showed that self-perceived health status was significantly associated with shared decision-making. Other health status–related factors outside shared decision-making, such as self-efficacy and extent of comorbidities, may contribute to ED use (31). More studies on self-perception and self-efficacy in adherence to treatment plans may provide more recommendations on how to enhance shared decision-making practices.

Limitations

Our study has several potential limitations. First, because our study was cross-sectional, only association, not causation, can be assessed. Second, because our data were self-reported, the potential for self-reporting and social desirability biases exists. Third, we used only 1 variable from the Andersen model for need factors and only 3 variables for enabling factors. Other components for need could include social determinants of health, and environmental-, policy-, and place-based factors. Fourth, an additional analysis could have been completed to assess health care providers' knowledge of the Andersen factors and how their perceptions may have affected the success of shared decision-making, but that was not possible with this public data set. Future studies should consider additional variables that may qualify for more expansive analysis. Fifth, alternative analysis methods to assess all Andersen model factors could have been used; for example, we could have used multinomial logistical regression to assess categorical values (comparing ED use at multiple levels) rather than binary values (0 ED visits vs ≥1 ED visits). Lastly, we omitted from analysis survey respondents younger than 18 years or not diagnosed with high blood pressure, which limits the generalizability of our study. However, given the objective of the study, we believe these exclusion criteria were reasonable.

Implications for public health

High blood pressure is a prevalent health problem in the US and worldwide. When uncontrolled, it may lead to preventable ED use and higher costs to the health system. By enhancing patient–provider communication and partnership through shared decision-making, patients may be able to improve their management of high blood pressure and not need to access emergency medical services. Health systems could consider implementing incentives for both patients and health care providers for successful chronic disease management. Future studies should expand on the perceived use of shared decision-making among people with chronic disease to improve health outcomes.

Conclusion

Increasing shared decision-making may be an effective method for reducing avoidable ED use and improving treatment adherence. Multiple factors in addition to shared decision-making may be contributing to rates of health care service use. The Andersen model is a useful tool for considering the various factors that contribute to health care use. Future health services research can build on this study to improve the health care infrastructure at large.

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Tables

Table 1. Descriptive Statistics of Final Analytic Sample in Study on Shared Decision-Making and ED Use Among Adults Aged ≥18 Years With a Diagnosis of High Blood Pressure, US, 2015–2019[a]

Variable	No. (%)
Total	30,407 (100.0)
Level of shared decision-making[b]	
Low	18,357 (60.7)
High	12,050 (39.3)
No. of visits to ED	
0	23,037 (76.7)
≥1	7,370 (23.3)
Predisposing factors[c]	
Age, y	
18–39	2,751 (9.5)
40–64	13,958 (46.2)
≥65	13,600 (44.3)
Sex	
Male	14,117 (49.3)
Female	16,290 (50.7)
Race and ethnicity	
Asian only	1,384 (4.1)
Black only	6,237 (13.7)
Hispanic	5,033 (10.5)
White only	16,832 (68.7)
Other or multiple races	921 (3.0)
Geographic region	
Northeast	4,879 (16.7)
Midwest	6,258 (21.8)
South	12,629 (40.9)
West	6,544 (20.5)
Highest educational degree earned	
No degree	4,822 (14.0)
High school diploma or GED	13,527 (54.7)
Bachelor's	4,087 (18.8)
Master's or doctorate	2,642 (12.5)
Body mass index[d]	
Underweight (<18.5)	361 (1.2)

Abbreviation: ED, emergency department; GED, General Educational Development.

[a] Data source: 2015–2019 Medical Expenditure Panel Survey (MEPS) (21). All data are weighted; percentages may not add to 100 because of rounding.

[b] Answers to 7 MEPS questions related to shared decision-making were used to develop a predictor variable for shared decision-making.

[c] The Andersen model (18,19) was used as a framework to explain how ED use was influenced by predisposing factors, enabling factors, and need factors, the 3 fundamental components of this model. Only 1 need factor applied to the MEPS data set.

[d] Calculated as body weight in kilograms divided by height in meters squared.

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Table 1. Descriptive Statistics of Final Analytic Sample in Study on Shared Decision-Making and ED Use Among Adults Aged ≥18 Years With a Diagnosis of High Blood Pressure, US, 2015–2019[a]

Variable	No. (%)
Normal (18.5 to <25.0)	2,118 (7.1)
Overweight (25.0 to <30.0)	3,518 (11.8)
Obese (≥30.0)	24,342 (79.9)
Personal belief in ability to “overcome ills without medical help”	
Disagree/uncertain	19,307 (86.7)
Agree	2,716 (13.3)
Enabling factors[c]	
Income	
High (>400% poverty line)	8,200 (42.5)
Middle (200%–400% poverty line)	7,024 (27.5)
Low (<200% poverty line)	9,743 (30.0)
Travel time to doctor’s appointment, min	
<15	13,378 (50.0)
15–30	10,559 (38.6)
31–60	2,733 (9.6)
>61	526 (1.8)
Health insurance	
Any private	17,001 (63.4)
Public only	12,116 (33.3)
Uninsured	1,290 (3.3)
Need factor[c]	
Self-perceived general health status	
Excellent	1,798 (6.9)
Very good	7,347 (28.4)
Good	11,411 (39.9)
Fair	6,549 (19.7)
Poor	1,689 (5.1)

Abbreviation: ED, emergency department; GED, General Educational Development.

[a] Data source: 2015–2019 Medical Expenditure Panel Survey (MEPS) (21). All data are weighted; percentages may not add to 100 because of rounding.

[b] Answers to 7 MEPS questions related to shared decision-making were used to develop a predictor variable for shared decision-making.

[c] The Andersen model (18,19) was used as a framework to explain how ED use was influenced by predisposing factors, enabling factors, and need factors, the 3 fundamental components of this model. Only 1 need factor applied to the MEPS data set.

[d] Calculated as body weight in kilograms divided by height in meters squared.

Table 2. Cross-Tabulation Analysis Between Variables and Outcome (ED Use) in Study on Shared Decision-Making and ED Use Among Adults Aged ≥18 Years With a Diagnosis of High Blood Pressure, US, 2015–2019[a]

Variable	No. of visits to ED, %		*P* value[b]
	No ED visit, %	≥1 ED visits	
Level of shared decision-making[c]			
Low	75.2	24.8	<.001
High	79.0	21.0	
Predisposing factors[d]			
Age, y			
18–39	76.7	23.3	<.001
40–64	79.0	21.0	
≥65	74.6	25.5	
Sex			
Male	79.6	20.4	<.001
Female	73.9	26.1	
Race and ethnicity			
Asian only	88.5	11.5	<.001
Black only	73.4	26.6	
Hispanic	78.5	21.5	
White only	76.8	23.2	
Other or multiple races	68.1	31.9	
Geographic region			
Northeast	76.5	23.5	.02
Midwest	75.5	24.6	
South	76.7	23.4	
West	78.8	21.2	
Highest educational degree earned			
No degree	69.9	30.1	<.001
High school diploma/GED	74.8	25.2	
Bachelor's	83.0	17.0	
Master's or doctorate	82.0	18.0	
Body mass index[e]			
Underweight (<18.5)	73.3	26.7	.03
Normal (18.5 to <25.0)	76.8	23.2	
Overweight (25.0 to <30.0)	79.1	20.9	
Obese (≥30.0)	76.4	23.6	
Personal belief in ability to "overcome ills without medical help"			

Abbreviation: ED, emergency department; GED, General Educational Development.

[a] Data source: 2015–2019 Medical Expenditure Panel Survey (MEPS) (21). All data are weighted.

[b] Determined by Pearson χ^2 test; $P \leq .05$ considered significant.

[c] Answers to 7 MEPS questions related to shared decision-making were used to develop a predictor variable for shared decision-making.

[d] The Andersen model (18,19) was used as a framework to explain how ED use was influenced by predisposing factors, enabling factors, and need factors, the 3 fundamental components of this model. Only 1 need factor applied to the MEPS data set.

[e] Calculated as body weight in kilograms divided by height in meters squared.

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Table 2. Cross-Tabulation Analysis Between Variables and Outcome (ED Use) in Study on Shared Decision-Making and ED Use Among Adults Aged ≥18 Years With a Diagnosis of High Blood Pressure, US, 2015–2019[a]

Variable	No. of visits to ED, %		P value[b]
	No ED visit, %	≥1 ED visits	
Disagree or uncertain	76.0	24.0	<.001
Agree	80.7	19.3	
Enabling factors[d]			
Income			
High (>400% poverty line)	82.5	17.5	<.001
Middle (200%–400% poverty line)	77.1	22.9	
Low (<200% poverty line)	69.3	30.7	
Travel time to doctor's appointment, min			
<15	77.2	22.8	<.001
15–30	76.7	23.3	
31–60	72.7	27.3	
>61	77.4	22.7	
Health insurance			
Any private	80.6	19.5	<.001
Public only	69.2	30.8	
Uninsured	78.6	21.5	
Need factor[d]			
Self-perceived general health status			
Excellent	88.9	11.1	<.001
Very good	85.6	14.4	
Good	77.7	22.3	
Fair	64.8	35.2	
Poor	51.8	48.2	

Abbreviation: ED, emergency department; GED, General Educational Development.

[a] Data source: 2015–2019 Medical Expenditure Panel Survey (MEPS) (21). All data are weighted.

[b] Determined by Pearson χ^2 test; $P \leq .05$ considered significant.

[c] Answers to 7 MEPS questions related to shared decision-making were used to develop a predictor variable for shared decision-making.

[d] The Andersen model (18,19) was used as a framework to explain how ED use was influenced by predisposing factors, enabling factors, and need factors, the 3 fundamental components of this model. Only 1 need factor applied to the MEPS data set.

[e] Calculated as body weight in kilograms divided by height in meters squared.

Table 3. Association Between Shared Decision-Making and ED Use in Study on Shared Decision-Making and ED Use Among Adults Aged ≥18 With a Diagnosis of High Blood Pressure, US, 2015–2019[a]

Variable	Odds ratio (95% CI)	*P* value[b]
High level of shared decision-making[c]		
Unadjusted	0.80 (0.75–0.86)	<.001
Adjusted	0.86 (0.76–0.97)	.01
Predisposing factors[d]		
Age, y		
18–39	1 [Reference]	
40–64	0.76 (0.62–0.93)	.007
≥65	0.94 (0.77–1.14)	.51
Sex		
Male	1 [Reference]	
Female	1.26 (1.11–1.43)	<.001
Race and ethnicity		
Asian only	0.42 (0.29–0.60)	<.001
Black only	1.01 (1.00–1.54)	.95
Hispanic	0.81 (0.66–0.99)	.04
White only	1 [Reference]	
Other or multiple races	1.36 (1.00–1.86)	.052
Geographic region		
Northeast	1 [Reference]	
Midwest	1.03 (0.87–1.22)	.75
South	0.90 (0.77–1.05)	.20
West	0.93 (0.78–1.11)	.43
Highest educational degree earned		
No degree	1 [Reference]	
High school diploma/GED	1.02 (0.85–1.23)	.81
Bachelor’s	0.92 (0.72–1.18)	.52
Master’s or doctorate	1.03 (0.81–1.32)	.80
Body mass index[e]		
Underweight (<18.5)	1 [Reference]	
Normal (18.5 to <25.0)	1.07 (0.76–1.50)	.71
Overweight (25.0 to <30.0)	0.94 (0.67–1.29)	.70
Obese (≥30.0)	1.06 (0.78–1.46)	.70
Personal belief in ability to “overcome ills without medical help”		
Disagree/uncertain	1 [Reference]	

Abbreviation: ED, emergency department; GED, General Educational Development.

[a] Data source: 2015–2019 Medical Expenditure Panel Survey (MEPS) (21). All data are weighted.

[b] $P \leq .05$ considered significant.

[c] Answers to 7 MEPS questions related to shared decision-making were used to develop a predictor variable for shared decision-making.

[d] The Andersen model (18,19) was used as a framework to explain how ED use was influenced by predisposing factors, enabling factors, and need factors, the 3 fundamental components of this model. Only 1 need factor applied to the MEPS data set.

[e] Calculated as body weight in kilograms divided by height in meters squared.

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Table 3. Association Between Shared Decision-Making and ED Use in Study on Shared Decision-Making and ED Use Among Adults Aged ≥18 With a Diagnosis of High Blood Pressure, US, 2015–2019[a]

Variable	Odds ratio (95% CI)	*P* value[b]
Agree	0.89 (0.75–1.06)	.19
Enabling factors[d]		
Income		
High (>400% poverty line)	1 [Reference]	
Middle (200%–400% poverty line)	1.14 (0.97–1.33)	.11
Low (<200% poverty line)	1.35 (1.16–1.58)	<.001
Travel time to doctor’s appointment, min		
<15	1 [Reference]	
15–30	1.01 (0.89–1.13)	.93
31–60	1.27 (1.06–1.53)	.01
>61	0.80 (0.50–1.26)	.33
Health insurance		
Any private	1 [Reference]	
Public only	1.22 (1.06–1.40)	.004
Uninsured	1.09 (0.77–1.53)	.64
Need factor[d]		
Self-perceived general health status		
Excellent	1 [Reference]	
Very good	1.31 (0.97–1.76)	.08
Good	1.91 (1.44–2.51)	<.001
Fair	3.39 (2.58–4.47)	<.001
Poor	5.44 (3.78–7.83)	<.001

Abbreviation: ED, emergency department; GED, General Educational Development.

[a] Data source: 2015–2019 Medical Expenditure Panel Survey (MEPS) (21). All data are weighted.

[b] $P \leq .05$ considered significant.

[c] Answers to 7 MEPS questions related to shared decision-making were used to develop a predictor variable for shared decision-making.

[d] The Andersen model (18,19) was used as a framework to explain how ED use was influenced by predisposing factors, enabling factors, and need factors, the 3 fundamental components of this model. Only 1 need factor applied to the MEPS data set.

[e] Calculated as body weight in kilograms divided by height in meters squared.

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ORIGINAL RESEARCH

An Exploratory Qualitative Analysis of Explanations for COVID-19–Related Racial Disparities Among St. Louis Residents: “I Don’t Really Pay Attention to the Racial Stuff Very Much”

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PEER REVIEWED

Summary

What is already known on this topic?

Public health and lay explanations for racial disparities in health outcomes often differ. This difference affects how people perceive their own health risks and their support for policies that address health disparities.

What is added by this report?

We examined the explanations that 54 St. Louis residents gave for COVID-19–related racial disparities in St. Louis. Although Black interview participants acknowledged the role of racism, White participants did not. Both groups emphasized personal responsibility.

What are the implications for public health practice?

Messaging that highlights racism may be less effective among the White population than the Black population in the US, whereas narratives that include the theme of individual choice may appeal to both.

Abstract

Introduction

Public health explanations for the disproportionate share of COVID-19–related illness and death among the Black population often differ from lay explanations, which can affect the public’s support for policies that address these disparities. This qualitative exploratory study examined the explanatory frameworks for COVID-19–related racial disparities in St. Louis among 54 St. Louis residents.

Methods

From August 16, 2021, through May 20, 2022, we conducted semistructured interviews among a convenience sample of 54 St. Louis residents about their experiences during the COVID-19 pandemic. Directed content analysis identified participants’ explanatory frameworks for racial disparities in COVID-19–related illness and death. We disaggregated coded excerpts by race, age, education, and income to examine emerging themes.

Results

Lay explanatory frameworks for racial disparities in COVID-19 included vaccine mistrust, lack of personal responsibility, low perceived susceptibility to COVID-19, pre-existing conditions or genetic predisposition, institutional racism, barriers to care, low socioeconomic status, insufficient information on COVID-19, and the inability to work remotely. Black interview participants addressed issues of systemic racism, inequitable allocation of COVID-19 vaccines, and institutional mistrust, whereas White participants did not directly acknowledge the role of racism. Both Black and White participants identified lack of personal responsibility among young Black people as a source of these disparities.

Conclusion

This work identifies a need for improved health communication about racial disparities in COVID-19–related illness and death. Messaging that highlights racism may be less effective among the White population than the Black population in the US, whereas narratives that include the theme of individual choice may appeal broadly. Further research is needed on the use of communication strategies based on lay individuals’ explanatory frameworks for

COVID-19–related racial disparities to enhance support for equitable public policy.

Introduction

Mirroring national trends, Black St. Louis residents have had disproportionate rates of illness and death from COVID-19 (1,2). The field of public health explains these racial disparities by implicating multiple adverse social determinants of health, including poverty, residential overcrowding, lack of health insurance, overrepresentation in the essential workforce, and systemic racism (3–5). The Black population in the US has also had lower rates of COVID-19 testing and vaccine uptake, although the reasons for these lower rates are not clear (5–10). Some studies indicate that vaccine hesitancy among the Black population is due to a well-founded mistrust of health care institutions predicated on contemporary and historical medical racism (6,11), a form of racism perpetuated by health care practices, teachings, and norms that include US government–sanctioned experiments on members of the Black population (eg, the Tuskegee Syphilis Study) and discriminatory patient–provider encounters. Other research has found no differences in willingness to participate in COVID-19 vaccination and testing between the White and Black population in the US (7), instead highlighting the inequitable rollout of COVID-19 vaccines, including in St. Louis (5,7–9). An overreliance on the role of mistrust in vaccine hesitancy potentially casts blame for lower vaccination rates on the Black population rather than on systemic issues of access and can further perpetuate medical racism.

Although US public health officials and the media have highlighted racial disparities in COVID-19–related illness and death, a growing body of evidence suggests that communicating about these disparities may have had the unintended consequence of making the White population feel less at risk than racial and ethnic minority populations for the severe outcomes of COVID-19 and less supportive of public health policies to address these disparities (12–14). This previous research focused more on educating the public on the existence of racial disparities in COVID-19 rather than examining the public's own explanations for these disparities. These explanations may contribute to the extent to which audiences are receptive to public health messages. Public health organizations often emphasize the role of social determinants of health in creating racial disparities in health outcomes, but the concept may not be reflected in the lay population's own explanatory frameworks (15). In this study, we define the lay population as people who do not have professional or academic knowledge of the field of public health. Literature on how the lay population explains health disparities demonstrates that the White population in the US often minimizes the role of racism and instead focuses on the effects of socioeconomic status, personal responsibility, and genetic vulnerability (15–21). The Black population in the US acknowledges the effect of racism but also asserts the role of individual choice (15,22,23).

The objective of this study was to identify lay explanations for racial disparities in COVID-19 illness and death in St. Louis and examine whether and how they differ by a person's race, education, income, and age.

Methods

This exploratory qualitative research used a portion of interviews from a larger mixed-methods cross-sectional study performed as part of the Health Communication Research Laboratory (HCRL) at Washington University in St. Louis's participation in the Center for Disease Control and Prevention's Prevention Research Center (PRC) Vaccine Confidence Network, which aims to build COVID-19 vaccine confidence and uptake in local communities (24). Eligibility requirements for participating in an interview included living in St. Louis or the St. Louis County metropolitan area at the time of the interview and being aged 18 years or older. Participants were recruited primarily through a convenience sample via distribution of a community-based flyer. We used this method of recruitment because it maximized the speed of data collection and the dissemination of data to local community partners during the rapidly changing pandemic environment. Institutional review board approval was obtained from Washington University in St. Louis.

From August 16, 2021, through May 20, 2022, two HCRL staff members conducted semistructured interviews with 54 participants about their experiences during the COVID-19 pandemic. The interview guide drew from the common data elements of the PRC Vaccine Confidence Network. Each interview lasted approximately 30 minutes and was conducted via Zoom (audio only). One interviewer identified as a young Black female and the other as an older White male. Interviews covered various topics, including the personal effect of COVID-19, the effect of the pandemic on the local community, perceptions and concerns about COVID-19 and the vaccine, and COVID-19–related racial disparities in St. Louis. We collected data on each participant's demographic characteristics (age, sex, race and ethnicity, education level, and income level) and asked questions about their COVID-19 vaccination status. We also asked whether they or someone close to them had contracted COVID-19 and, if so, whether that person had been hospitalized or died. Each participant received a $50 Target gift card for their time.

The 54 audio-recorded interviews were professionally transcribed verbatim. One coder (C.K., who identifies as a young White female) performed directed content analysis on the transcripts (25,26) and examined the response to the question, “In St. Louis, Blacks have been affected more by COVID than other groups. Why do you think that is?” The codebook included the a priori code “Impact_Blacks” to identify the relevant interview sections and emerging subcodes relating to explanations for racial disparities in COVID-19. The coder (C.K.) performed 3 rounds of coding and updated the codebook after each round. After the second round of coding, the codebook was discussed by the initial coder and 2 members of the HCRL team (M.A.J. and M.M.K.) who had previously coded the data for other internal research reports. The final round of coding resolved any inconsistencies and grouped findings into themes. Representative quotes were extracted for each theme. All coding was performed in NVivo 20 (QSR International). An audit trail was created with detailed notes throughout the coding process. Data saturation was achieved.

After the 3 rounds of coding were completed, the coded interview excerpts were disaggregated by demographic characteristic: race (non-Hispanic Black [hereinafter, Black], non-Hispanic White [hereinafter, White], “Other,” or refused); education level (less than college, some college or 4-year degree, or other advanced degree); annual household income (<$25,000, $25,000 to <$75,000, ≥$75,000, or refused); and age (19–45 or >45 years, with groups based on a histogram analysis of age distribution). For the purposes of this study, study participants who identified as Asian, Hispanic or Latino, or an unspecified race or ethnicity were grouped into “Other” because differences and similarities in explanations for COVID-19 racial disparities between Black and White participants were of primary interest. We also examined potential themes by education, income, and age among participants.

Results

Most (61.1%) participants were non-Hispanic Black and most (81.5%) were women. Overall, 49 (90.7%) were vaccinated. Of the 5 unvaccinated participants, 3 were non-Hispanic Black and 2 identified as “other” race and ethnicity. The mean age was 46.8 years, ranging from 21 to 73 years. More Black participants (n = 17) than White participants (n = 4) indicated knowing someone in their social network who had been hospitalized or died as a result of COVID-19 (Table 1). Explanations for COVID-19–related racial disparities in St. Louis highlighted both individual and systemic factors (Table 2), and the 2 factors were often related (eg, personal mistrust in the COVID-19 vaccine and systemic racism). Individual factors included mistrust of the COVID-19 vaccine because of past government experiments on the Black population or conspiracy theories, lack of personal responsibility (particularly among young people in the Black community), low perceived susceptibility to COVID-19, and increased risk due to pre-existing conditions or genetic predisposition. Systemic factors encompassed institutional racism (eg, medical racism); barriers to COVID-19 care (eg, lack of transportation or health insurance); low socioeconomic status; insufficient information on COVID-19; and the inability to work remotely. Some participants (n = 8) denied any knowledge of these racial disparities and refused to speculate.

The most notable differences in lay explanations for COVID-19–related racial disparities in St. Louis occurred along racial lines rather than by education, income, or age. We found no major differences across unique combinations of demographic characteristics (eg, Black females with less than a college education), perhaps because we did not achieve data saturation among small subgroups.

Black participants

Black participants emphasized the historical role of the US government in perpetuating racism and the contemporary role of medical racism in vaccine hesitancy and mistrust of government and hospitals among Black St. Louis residents. They frequently mentioned government experimentation and the Tuskegee syphilis study, with 1 participant stating, “There’s just been a bad history of experimentation and stuff. Black people don’t trust doctors in hospitals” (Black female, aged 43). Unlike White participants, Black participants directly identified the role of medical racism and discrimination in their mistrust of the COVID-19 vaccine and hospitals: “We always the most affected, I guess because we’re the most experimented on. Then medical racism is a real thing because you can go to the doctor and be in pain and tellin’ them that you’re in pain but they’ll think you just lyin’” (Black female, aged 48).

Black participants also highlighted barriers among Black St. Louis residents to being healthy or receiving medical care, including poverty and lack of health insurance. One participant identified residential overcrowding as increasing the risk for COVID-19: “Their economic situation. A lotta African Americans are forced to cohabitate together, so you can have 10 people in a 2-bedroom home” (Black female, aged 64). Black participants also noted the effect of delayed access to information about the COVID-19 pandemic and lack of vaccine prioritization, despite the disproportionate share of COVID-19–related illness and death in the Black population: “They weren’t given priority with the vaccine even though the majority of us were dying and more of us were dying than any other population” (Black female, aged 59).

On a more individual level, Black participants frequently referred to the lack of perceived susceptibility to, and severity of, the disease among the Black population, which they implied may have led to riskier behaviors and more frequent infections compared with other racial and ethnic groups. Several participants noted that some Black people did not think they could contract COVID-19, although it is unclear from the interviews why they believed this: “Some of the Black people that I know said — would think that — that it was only White people was getting it and all that, ‘Well, we don’t get that kinda stuff’” (Black male, aged 54). Another participant expressed the idea that young people in her community were not worried about the potential severity of COVID-19: “Over here with our young people, the message was not connecting well, and they were told, it’s not going to impact you. It’s more the senior population” (Black female, aged 53).

White participants

Although White participants noted the potential role of poverty in COVID-19–related racial disparities in St. Louis, they never directly mentioned the words “racism” or “discrimination.” Instead, they vaguely alluded to these concepts as primarily historical rather than contemporary phenomena: for example, a “horrible history” (White female, aged 63), “long and terrible story” (White female, aged 73), “not-so-good history” (White female, aged 35).

Several White participants asserted that Black people are more likely to get COVID-19 either because of “genetic predisposition” to the virus itself (White female, aged 56) or poor health from living in their communities. One participant explained, “I would say it’s health in general because a lot of African Americans are not healthy. They live in blighted communities” (White female, aged 61).

More White participants than Black participants denied any knowledge of COVID-19–related racial disparities in St. Louis, with one respondent stating, “I don’t really pay attention to the racial stuff very much” (White female, aged 36). When asked about her own race, she reported that she is “unfortunately . . . Caucasian,” seeming to potentially indicate her discomfort in talking about the topic.

Similarities between Black and White participants

Both Black and White participants often referred to a lack of personal responsibility, particularly among young Black people, as causing COVID-19–related racial disparities in St. Louis. This idea often, although not always, was expressed by participants aged 30 years or older who were speaking about people younger than themselves. One woman explained, “Maybe because we’re [Black people are] not as cautious, could be, because people are still going out partying, the younger generation, partying in clubs, not wearing masks, they don’t wear masks in the store” (Black female, aged 67). Although some participants attributed this behavior among young people to their perceived lack of susceptibility to COVID-19, others viewed it as a lack of regard for anyone other than themselves: “Because [young people] do whatever they want and don’t care. They don’t wear masks. . . . A lot of those and the youngsters out here have no guidance. None, they aren’t just bad mistakes for that because they don’t give a f—, sorry, they don’t care, they get what they want” (White female, aged 34).

Discussion

This exploratory qualitative study of St. Louis residents’ explanations for COVID-19–related racial disparities found that Black study participants often attributed these disparities to systemic racism and its role in vaccine hesitancy, misallocation of COVID-19 vaccines, and general mistrust of governmental and medical institutions. Notably, White participants never directly mentioned “racism” or “discrimination,” instead obliquely referencing injustices against Black Americans as a past (rather than continued) reason for disparities. Both Black and White participants noted a lack of personal responsibility, particularly among young Black people, as a factor contributing to COVID-19’s racial disparities in St. Louis. However, only Black participants addressed the issue of perceived susceptibility and severity, with several stating that they thought Black people, especially young ones, believed they could not get COVID-19, get very sick from it, or transmit it. These ideas somewhat mitigate the personal responsibility explanatory framework that otherwise implies a selfish and willful disregard for community health. Finding scapegoats during public health crises is common, and one group who often faces blame are those viewed as not following public health precautions, such as young people (27).

Our study results mirror previous research on differences between how White and Black Americans explain health disparities. That a White participant endorsed a genetic explanation for COVID-19’s racial disparities is consistent with previous literature (16,19). Our study also supports previous research that White Americans recognize poverty as a contributing factor more than racism (20,21). This viewpoint reflects White participants’ failure to address contemporary racism and discrimination, instead acknowledging neighborhood-level factors, such as poverty, independently of the structural racism at the root of segregated neighborhoods and poor health outcomes. Notable is one participant’s use of the phrase "blighted communities.” The term “blight” has a racist history in urban planning: largely low-income Black communities were declared “blighted” as a means of driving those populations out through various development projects (28). Declaring Black communities as “blighted” (28) and beyond repair without external remediation naturalizes disease within these communities and justifies allegedly race-neutral “cures” that primarily protect adjacent

White middle and upper-class property values by preventing spread of the "blight" (28).

Aligning with previous studies (15–21), the role of personal responsibility and individual choice emerged as a key explanatory framework for COVID-19–related racial disparities among both Black and White study participants. Although Black Americans may acknowledge the importance of both personal responsibility and racism, researchers have found that it is difficult for many White Americans to disrupt their belief in the myth that contemporary society is just (29). When forced to examine their own privilege, individuals often uplift ideas of personal merit, rendering systemic inequities invisible (30).

Lay and public health explanations for COVID-19's racial disparities did overlap in some areas, including how poverty, barriers to COVID-19 care, vaccine hesitancy, and overrepresentation in the frontline workforce contributed (3). We also found important differences between the study participants' explanations and public health explanations, particularly interviewees' emphasis on personal responsibility. This emphasis potentially moralizes the issue and casts blame on those who contract COVID-19. Framing health as a strictly personal endeavor helps to mask deeper systemic inequities and prevent their disruption.

It is important to garner public support for policies to reduce racial disparities not only in COVID-19 outcomes but also for other conditions that disproportionately affect racial and ethnic minority populations. Individuals' explanatory frameworks for illness influence whether they view poor health as a personal failing, societal responsibility, or both. Our study suggests that White Americans may be less receptive than Black Americans to acknowledging racism as an underlying cause of health disparities. Communication strategies for the social determinants of health similarly recommend against framing health disparities as a primarily racial issue to avoid fostering negative bias from White participants (15). Both Black and White participants often viewed infection with COVID-19 as more of an individual choice than a systemic inevitability. Narratives that emphasize providing everyone the equal opportunity to exercise personal responsibility over their own health might be more broadly accepted, although the potential for this rhetoric to further entrench an individualism blind to systemic issues should be acknowledged (15). Randomized control trials might offer study participants various messages and then evaluate their receptiveness to those communication strategies based on their own explanatory frameworks.

Strengths and limitations

Our study helps fill the absence in the literature of lay explanations for racial disparities in COVID-19. It is the only study to date that specifically explores how Black and White Americans explain COVID-19–related racial disparities. Although other studies assessed the association between participant education on racial disparities in COVID-19 and individuals' consequent support of government intervention, none have examined people's explanatory frameworks for these disparities (12–14). Some of these studies have incorporated measures of racial prejudice (12,14), but without examining participants' personal explanations for racial disparities, it is difficult to design communication campaigns to enhance support for addressing these disparities. The qualitative nature of this study also elevates the lived experiences of St. Louis residents and demonstrates that lay explanations for poor health are often removed from public health explanations.

Our study has several limitations. Participants were selected as a convenience sample and selection bias likely affected who chose to be interviewed, including the fact that most of the sample had been vaccinated. The primary goal of qualitative research, however, is not generalizability, and the rich insight into local contexts outweighs these drawbacks. It is also difficult to tell whether White participants' relatively limited knowledge of COVID-19's racial disparities was true ignorance or a hesitancy to answer a potentially sensitive question. The 2 interviewers had distinctly different positionalities (a young Black female and an older White male) that could have affected their conversations with participants, although the Zoom calls did not use video. Although the primary coder's positionality as a White woman inevitably affected her analysis of the data, the racial and ethnic diversity of the larger HCRL team contributed to creating an unbiased interpretation.

Conclusion

Our study found that Black and White St. Louis residents have different explanations for COVID-19's racial disparities in their city. Although Black participants acknowledged the role of racism, White participants did not. Both groups underscored the importance of personal responsibility. Future research should build the evidence base for better tailored messaging about racial disparities in COVID-19 and other health outcomes. Without understanding how people make sense of health disparities, public health risks 2 potentially harmful outcomes: wasting resources on ineffective messaging or, worse, further entrenching individuals' negative attitudes toward specific groups of people or support for government intervention.

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Tables

Table 1. Key Demographic Characteristics of Participants (N = 54) in Interviews About Reasons for COVID-19–Related Racial Disparities, St. Louis, Missouri, August 2021–May 2022[a]

Characteristic	No. (%)[b]
Age, mean (range)	46.8 (21–73)
Sex	
Female	44 (81.5)
Male	10 (18.5)
Race and ethnicity	
Non-Hispanic Black	33 (61.1)
Non-Hispanic White	14 (25.9)
Other[c]	7 (13.0)
Education level	
Less than college	16 (29.6)
Some college or 4-year degree	30 (55.6)
Other advanced degree	8 (14.8)
Household income in 2020, $	
<25,000	13 (24.1)
25,000–74,999	26 (48.1)
≥75,000	11 (20.4)
Refused	4 (7.4)
COVID-19 vaccination status	
Yes	49 (90.7)
No	5 (9.3)
Unvaccinated status, by race	
Non-Hispanic Black	3 of 5 (60.0)
Non-Hispanic White	0
Other	2 of 5 (40.0)
Someone in social network hospitalized or died as a result of COVID-19, by race	
Non-Hispanic Black	17 of 33 (51.5)
Non-Hispanic White	4 of 14 (28.6)
Other	3 of 7 (42.9)

[a] From August 16, 2021, to May 20, 2022, semistructured interviews were conducted with a convenience sample of 54 St. Louis residents about their experiences during the COVID-19 pandemic.

[b] Values are number (percentage), except for age. Denominator for all percentages is 54, unless otherwise indicated.

[c] For the purposes of this study, study participants who identified as Asian, Hispanic or Latino, or an unspecified race or ethnicity were grouped into “Other” because differences and similarities in explanations for COVID-19 racial disparities between Black and White participants were of primary interest.

Table 2. Explanations for COVID-19–Related Racial Disparities Identified by Interview Participants (N = 54), St. Louis, Missouri, August 2021–May 2022[a]

Theme	Representative quotes	Race and age, y, of participant
Individual factors		
Vaccine mistrust as product of history of government experimentation on Black people	African Americans have a history, as you well know, not only of past discrimination but discrimination up until this day to the point where we've been experimented on with different medications and things like that. First, it was a lot of people, Black people, bein' affected because they didn't trust the vaccine.	Black female, 64
	When they were giving those Black men in Africa syphilis, to see how fast they would die. They told them it was something for something else. We know, we remember. We don't need to have all the information. We just know that something happened. Then it involve White guys and needles.	Black male, 35
Vaccine mistrust as product of conspiracies or misinformation	Because they are listening to conspiracy theories...Well, one's the conspiracy is Bill Gates. . . . Yeah, Bill Gates is a hit man for government.	Black female, 72
	I think maybe misinformation that already preys on the mistrust that exists in the city.	White female, 26
Lack of personal responsibility	They don't want to take the vaccine, and they're not staying in. They can't be confined in the home. . . . They're used to going out doing what they're doing, and they just don't listen.	Black female, 67
	A lot of the younger people — when I say younger, I'm gonna say 35 and under. They don't know how to sit in the house. What I mean by that is, if you tell us that, 'Oh, you gotta stay in the house,' we're gonna stay for a certain amount of time. Then it's like oh, I'ma take a chance. Next thing you know, you start seeing parties.	Black male, 35
Lack of perceived risk	They don't believe what the numbers are telling them. Young people don't believe that it can affect them. They don't believe they can get COVID or give it to their relatives.	Black female, 41
	I think a lot of it is because you got people that does not take stuff serious. They take things for granted. I think a lot of people didn't think that COVID was as bad as it was.	Black female, 65
Increased risk due to pre-existing conditions or genetic predisposition	Because we [Black people] have more existing conditions probably than any other race.	Black male, 35
	Well, it seems to me, I got the impression that they [Black people] had a genetic predisposition.	White female, 56
Systemic factors		
Institutional racism (eg, medical racism) and resulting mistrust	When you're Black, you naturally have a distrust for the medical community.	Black male, 35
	I would assume it has to do with just the general distrust in health care or the health system, given some not-so-good history there.	White female, 35
Barriers to COVID-19 care (eg, availability of transportation, access to vaccines or testing, health insurance)	One, because a lot of us don't have insurance.	Black female, 64
	They [Black people] wanted the vaccinations as soon as they came [per a Black colleague]. I really don't know if it's because they didn't have the same access.	White female, 56
Low socioeconomic status	Because of the economic despair in the Black community, they fall victim to COVID a lot easier and a lot quicker.	Black male, 54
	I do think it has a lot to do with the socioeconomic divide here in St. Louis. . . . Along with many White people, a lot of African Americans are in that lower end as well.	White female, 35
Lack of information on COVID-19	Probably because they [Black residents] don't get the same information as we do.	White female, 61
	Also, because a lack of education or information that the people needed to go farther to get help. Because they didn't have the – they wasn't educated on the vaccines and educated on what could happen, a lot of 'em just felt like they'd just take their chances.	Black female, 65
Inability to work remotely	A lotta the people that we – that I function with and serve are people who have some of the frontline jobs. Meaning, they're grocery store clerks, or they're janitors, or they're people who actually had to keep working all through the pandemic.	White female, 63
	We were the ones on the front lines. We were the ones that were working at the McDonald's, at the hotels, so more of us were working there and more of us were getting sick because we were on the front line other than the nurses. We were in the restaurants. We were in the hotel industries. We were in those minimum wage jobs.	Black female, 59

[a] From August 16, 2021, to May 20, 2022, semistructured interviews were conducted with a convenience sample of 54 St. Louis residents about their experiences during the COVID-19 pandemic.

(continued on next page)

(continued)

Table 2. Explanations for COVID-19–Related Racial Disparities Identified by Interview Participants (N = 54), St. Louis, Missouri, August 2021–May 2022[a]

Theme	Representative quotes	Race and age, y, of participant
Other		
Lack of knowledge of racial disparities	I actually wasn't aware of that. . . . I don't really pay attention to the racial stuff very much.	White female, 36
	Oh gosh, I don't know. I really don't know. I have no knowledge of that.	White female, 60

[a] From August 16, 2021, to May 20, 2022, semistructured interviews were conducted with a convenience sample of 54 St. Louis residents about their experiences during the COVID-19 pandemic.

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ORIGINAL RESEARCH

Investigating the Relationship Between Physical Activity Disparities and Health-Related Quality of Life Among Black People With Knee Osteoarthritis

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PEER REVIEWED

Summary

What is already known on this topic?

Knee osteoarthritis is a debilitating condition that compromises a person's health-related quality of life.

What is added by this report?

Our findings highlight racial health disparities that exist in psychological, behavioral, and well-being variables among people with knee osteoarthritis. Specifically, the serial-mediated model explained the process of why Black individuals experience lower health-related quality of life than their White counterparts.

What are the implications for public health practice?

Health care providers should be aware of discrepancies in physical activity participation that might affect health-related quality of life among people with knee osteoarthritis. They should also prescribe physical activity as a self-management and lifestyle change for Black patients, along with providing holistic interventions that incorporate depression and lifestyle management.

Abstract

Introduction

Knee osteoarthritis (OA) is the most common form of arthritis, which is a leading cause of disability. Although no cure exists for knee OA, physical activity has been shown to improve functionality, which can improve an individual's health-related quality of life (HR-QOL). However, racial disparities exist in participating in physical activity, which can result in Black people with knee OA experiencing lower HR-QOL compared with their White counterparts. The purpose of this study was to investigate disparities of physical activity and related determinants, specifically pain and depression, and how these constructs explain why Black people with knee OA experience low HR-QOL.

Methods

Data were from the Osteoarthritis Initiative, a multicenter longitudinal study that collected data from people with knee OA. The study used a serial mediation model to test whether a change in scores for pain, depression, and physical activity over 96 months mediated the effects between race and HR-QOL.

Results

Analysis of variance models found Black race to be associated with high pain, depression, and lower physical activity and HR-QOL at baseline and month 96. The findings supported the prospective multi-mediation model, which found pain, depression, and physical activity to mediate between race and HR-QOL ($\beta = -0.11$, SE = 0.047; 95% CI, −0.203 to −0.016).

Conclusion

Disparities in pain, depression, and physical activity could explain why Black people with knee OA experience lower HR-QOL compared with their White counterparts. Future interventions should address sources of pain and depression disparities by improving health care delivery. Additionally, designing race- and culture-appropriate community physical activity programs would help to achieve physical activity equity.

Introduction

Knee osteoarthritis (knee OA), which is the most common form of osteoarthritis, is a leading cause of disability (1) and affects an individual's health-related quality of life (HR-QOL) (2). HR-QOL is a multidimensional construct that assesses the extent to which an individual's health condition or symptoms may interfere with their daily activities, such as physical functioning, social functioning, and mental health (3). HR-QOL has been proven to be disproportionately lower among Black people compared with their White counterparts across several clinical samples, including people with dementia (4), cancer patients (5,6), and stroke patients (7), and this pattern is consistent among people with knee OA (8–10). Therefore, identifying the important biopsychosocial factors that might explain racial disparities attributed to HR-QOL among knee OA patients is an essential step to redress the observed health disparity.

An established determinant of HR-QOL among people with knee OA is physical activity (11). Physical activity provides a multitude of benefits that promote healthy aging and specifically has been found to improve HR-QOL among people who experience chronic pain (12). Additionally, physical activity contributes to joint health by strengthening muscles around the joint and prevents cartilage deterioration, which helps improve knee mobility and in turn leads to improved physical functionality, both of which are determinants of HR-QOL (3). Because of these benefits, physical activity is often recommended as behavioral treatment of knee OA, as even low-intensity physical activity levels are effective in improving HR-QOL (13). Racial disparities exist in physical activity participation; Black people participate less than their White counterparts, and this disparity extends to people with knee OA (14). Being diagnosed with knee OA brings additional challenges that can cause participation in physical activity to deteriorate, specifically among Black people (15). One of the challenges is the high prevalence of depression among people with knee OA that might exacerbate the barriers to participating in physical activity (16) in the form of loss of interest in activities (17) and reduced energy (18).

Symptoms of depression can also manifest from experiencing pain that may hinder people with knee OA from engaging in their activities of daily living and self-care (19). In addition, emerging findings continue to show that Black Americans report experiencing higher levels of pain and disability compared with their White counterparts (20,21). Despite the evidence emphasizing racial disparities in pain, depression, and physical activity participation, how these factors explain the racial disparities in HR-QOL is unclear.

The rationale for the proposed conceptual model was derived from the Biopsychosocial Model of Pain (BPS Model) for osteoarthritis pain, where experiencing pain is the core of psychological (stress, mood, depression), behavioral (sleep, exercise, diet), and social (occupation, social support) dysfunction among knee OA patients, which accounts for biological factors (22). Although pain can affect each factor independently, the BPS Model demonstrates a dynamic relationship among psychological, behavioral, social, and biological factors. For instance, experiencing pain contributes to increasing the likelihood of developing affective disorders such as anxiety and depression (23). A negative affect such as depression may be a pre-existing risk factor for chronic pain; however, the result of a causal analysis indicated that pain caused depression among rheumatoid arthritis patients over a 6-month period (24). Recent studies have supported this causal relationship (25), and a systematic synthesis of the top 100 studies that cited pain and depression found that 47% demonstrated a causal relationship between pain and depression (26,27). Furthermore, depression is a psychological factor that has a behavioral impact resulting in less interest in self-care behaviors such as physical activity. In a longitudinal study that tracked women for 32 years, higher depression predicted less subsequent physical activity (28). Physical activity is a prominent determinant of HR-QOL among people with knee OA, as supported by systematic reviews (29,30), as are other factors in the BPS model such as pain (31) and depression (32). To determine whether relationships among the discussed factors from the BPS model are distinct between Black and White people, we developed a conceptual model that proposes the direct and indirect relationships among pain, depression, physical activity, and HR-QOL accounting for race (Figure). We aimed to understand the determinants of HR-QOL disparities associated with knee OA among Black and White people, using a large sample of patients with knee OA.

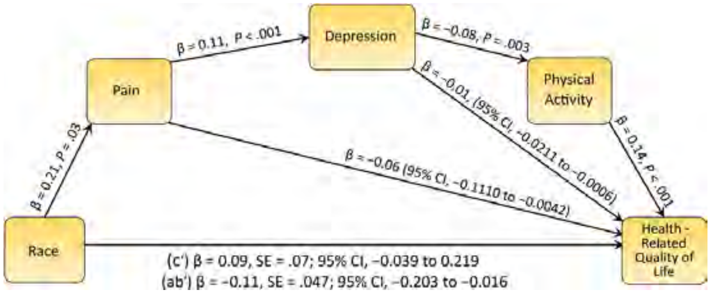

Figure. Mediation model of the association between race and quality of life by pain, depression, and physical activity (N = 1,498).

Methods

The primary objective of this study was to test racial differences in physical activity, HR-QOL, depression, and pain among a large sample of people with knee OA. In accordance with the literature and mentioned postulations, we hypothesized that Black people would report higher levels of pain and symptoms of depression and lower physical activity levels and HR-QOL, compared with their White counterparts. The secondary objective was to test the conceptualized serial mediation model. We hypothesized that race would predict pain (H1), and pain would predict depressive symptoms (H2). Depressive symptoms would predict physical activity

(H3), which in turn would predict HR-QOL (H4). We also hypothesized that these pathways would mediate the relationship to explain why Black people with knee OA experience lower HR-QOL (H5).

The Osteoarthritis Initiative is an ongoing observational study funded by the National Institutes of Health that tracks people who are at high risk for or are diagnosed with knee OA at the time of the study. The study was conducted at 4 sites: Baltimore, Maryland; Columbus, Ohio; Pittsburgh, Pennsylvania; and Pawtucket, Rhode Island. The study received institutional review board approval at each participating site and at Northwestern University. We conducted a secondary data analysis using data from 2006 through 2014 from the Osteoarthritis Initiative Data Repository (https://nda.nih.gov/oai/) (33).

Participants (N = 2,603) were adults diagnosed with knee OA who self-identified as White (n = 2,088) or Black (n = 515). All participants provided informed consent before enrollment. In the original study, data were collected on 9 occasions; we used data that were collected at baseline and year 8.

Measures

We analyzed data from the latest released variables that were relevant for the investigation, which was identified as meeting/year 8. The following measures collected at baseline (T1) and year 8 (T2) were used for the study.

Knee pain. The pain subscale (5 items) of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) is a psychometrically sound instrument that was used to assess the experience of pain symptoms related to knee OA (34).

Depression symptomology. Symptoms of depression were measured using the Center for Epidemiologic Studies Depression Scale (CES-D-20) (35). The CES-D-20 is a 20-item questionnaire that assesses 4 domains: positive mood (4 items), depressed mood (8 items), physical symptoms (6 items), and interpersonal relationships (2 items). Each item is framed on a scale of frequency of symptoms that range from 0 (little or no symptoms) to 3 (often). CES-D-20 total score ranges from 0 to 60 with a score of 16 or higher indicating depressive symptoms (35,36). Research suggests that a higher score is correlated with poorer health (35).

Physical activity. The Physical Activity Scale for the Elderly (PASE) was administered to measure physical activity levels. PASE comprises 12 items that assess a participant's activities during the previous week to report the frequency, duration, and intensity (light, moderate, strenuous) of activities such as walking outside of home, strength or endurance exercise, light and heavy housework, lawn work, home repair, gardening, caregiving, sport and recreational activities (with light, moderate, or strenuous effort), and work (for pay or volunteer). Participants were asked, "Over the past 7 days, how often did you do any exercises specifically to increase muscle strength and endurance, such as lifting weights or pushups, etc.?" with responses of 1) never, 2) seldom (1 or 2 d/wk), 3) sometimes (3 or 4 d/wk), and 4) often (5–7 d/wk). Response options rated the frequency of the activities as less than 1 hour per day, 1 to less than 2 hours per day, 2 to 4 hours per day, and more than 4 hours per day. Overall PASE scores can range from 0 to 739, with higher scores indicating higher levels of physical activity. PASE has shown excellent reliability among people with knee pain (37).

Health-related quality of life. The Short Form Health Survey 12 (SF-12) was administered to measure HR-QOL (3). The SF-12 assesses multiple domains including general health, physical functioning, mental health, and role limitations that stem from physical and mental problems. Participants were asked to consider their experience over the past 4 weeks to rate items such as "How often did physical health result in being limited in kind of work or other activities?" and "How much did pain interfere with normal work (include work outside home and housework)?" Responses options were 1) not at all, 2) a little bit, 3) moderately, 4) quite a bit, and 5) extremely. Four items of the SF-12 have reversed scoring (items 1, 8, 9, and 10), with a total score range from 0 to 100 where higher scores indicate better HR-QOL (38).

Analysis

We conducted normality tests based on recommendations and guidelines (39) and reported participant characteristics and measures of central tendency and correlations for variables of interest. The primary hypothesis was tested using 2 sets of analysis of variance (ANOVA) models to assess whether race (Black or White) of participants was associated with differences in pain, depression, physical activity, and HR-QOL at baseline and follow-up. Significant differences in outcome variables were further tested in the mediation analyses to determine whether change in these outcomes was determined by race. The serial mediation model was constructed and tested by using the PROCESS macro (v. 4.1) for SPSS (IBM Corporation) (40). All variables in the model were reported as changes in *z*-score values by regressing the Time-2 variable over its baseline (Time-1) measure, which is a well-documented approach (41,42). Significance was determined by using 95% bias-corrected CIs, which were computed from 5, 000 bootstrapped samples. The model tested whether race predicted change in pain scores (X1), followed by whether pain scores predicted depression (X2), and whether depression predicted change in physical activity (X3). Finally, we tested whether physical activity predicted change in HR-QOL (X4). This pathway represents the serial mediation, and successful mediation was denoted if the CI of the total indirect effect (X1–X4) did not include zero and if the direct pathway was no longer significant (40). The model controlled for nonmutable covariates including socioeconomic status (education, income, occupation) (43) and age. The model was then reanalyzed to additionally control for mutable factors, specifically body mass index (BMI).

Results

Of the 2,603 participants analyzed, 80.2% (n = 2,088) were White and 19.8% (n = 515) were Black; the average age of White participants was 68.6 (SD, 9.0) years, and the average age of Black participants was 65.9 (SD, 8.4) years (Table 1). The average BMI was 28.9 (SD, 4.6) kg/m^2 for White participants and 32.2 (SD, 4.8) kg/m^2 for Black participants; most participants were female (n = 1,516 [58.2%]). Normality tests indicated that baseline values of pain, depression, physical activity, and HR-QOL were within normal range (skewness: 0.59; kurtosis: −0.002).

Bivariate correlations indicated that race was correlated with pain (T1: $r = 0.35$, $P < .001$; T2: $r = 0.28$, $P < .001$), depression (T1: $r = 0.11$, $P < .001$; T2: $r = 0.11$, $P < .001$), physical activity (T1: $r = -0.06$, $P = .002$; T2: $r = 0.09$, $P < .001$), and HR-QOL (T1: $r = -0.27$, $P < .001$; T2: $r = -0.18$, $P < .001$). The ANOVA that tested baseline differences between races found significant differences in pain ($F_{1,2579} = 365.33$, $P < .001$), depression ($F_{1,2340} = 29.30$, $P < .001$), physical activity ($F_{1,2587} = 9.83$, $P = .002$), and HR-QOL ($F_{1,2567} = 205.73$, $P < .001$). Black participants experienced higher pain 10.0 (SD, 7.7) and depression 26.5 (SD, 7.4), with poorer HR-QOL 42.4 (SD, 8.7) and lower levels of physical activity 144.8 (SD, 87.0) compared with their White counterparts (Table 2). The same pattern was observed at follow-up: Black participants indicated worse pain 8.9 (SD, 8.4) and depression 26.3 (SD, 6.1) and lower HR-QOL 42.1 (SD, 9.3) and levels of physical activity 128.9 (SD, 82.0) compared with their White counterparts. The significant differences in health determinants between races at both points supported the testing of these variables in the serial mediation model. The remaining correlations can be found in Table 3. The serial mediation model (Figure) indicated that race predicted pain ($\beta = 0.21$, $P = .03$), pain to predict depression, ($\beta = 0.11$, $P < .001$), depression to predict physical activity, ($\beta = -0.08$, $P = .003$), and physical activity to predict HR-QOL ($\beta = 0.14$, $P < .001$). The total indirect pathway found race to mediate the relationship from X1 to X4 ($\beta = -0.11$, SE = .047; 95% CI, −0.203 to −0.016), in favor of White race of higher HR-QOL, while the direct pathway crossed through zero ($\beta = 0.09$, SE = .07; 95% CI, −0.039 to 0.219), thus meeting the requirements for successful mediation effect. The same pattern was found when also controlling for BMI, which yielded a significant indirect effect ($\beta = -0.11$, SE = .051; 95% CI, −0.213 to −0.009), and a nonsignificant direct effect ($\beta = 0.12$, SE = .07; 95% CI, −0.012 to 0.260).

Discussion

We found that, compared with their White counterparts, Black people experienced higher levels of pain and depressive symptoms and lower physical activity participation and HR-QOL, at baseline and follow-up. The secondary objective, which included testing a set of hypotheses related to the conceptual model, was also supported. The serial mediation model indicated that disparities experienced in pain, depression, and physical activity explained why Black people with knee OA experience lower HR-QOL than White people with knee OA.

We also found that Black participants experienced disparities in biopsychosocial predictors, which included higher levels of pain and symptoms of depression compared with White participants. These findings correspond with previous investigations on racial discrepancies in pain across various clinical groups (44–46), including patients with knee OA (20). Although racial disparities in experiencing depressive symptoms have been noted across community-dwelling older adults (44) and in clinical groups that include cancer (45) and stroke (46) patients, our findings among people with knee OA are congruent with and extend the literature to further highlight the importance of this disparity (47) by showing what factors might contribute to racial disparities attributed to depressive symptoms. Specifically, the predictive pathways among biopsychosocial determinants that included race to predict pain, which in turn predicted depression, explain this effect. Although pain among people with knee OA can be both static and dynamic, the aversive chronic sensation, combined with conscious regulation on limiting one's activities, can explain how this determinant predicts depression. Racial disparities of pain can be traced from discrepancies on how the pain is managed. In health care settings, Black patients are more likely to be subjected to stereotypes and false beliefs (48) from their primary care providers. A recent meta-analysis identified disparities in the prescription of medications, specifically regarding physicians refuting the pain experience of Black patients (21). Additionally, health care providers spend less time and provide fewer behavioral pain management approaches (49) with Black patients compared with White patients, which could explain why fewer Black people engage in self-management behaviors for pain control and alleviation (50).

Congruent with our hypotheses, physical activity levels were lower among Black participants than among White participants. In addition to the debilitating effects of depressive symptoms that dampen physical activity behavior, Black people experience inequitable societal experiences that discourage participation (51).

This can be attributed to their experience on receiving exercise prescription by health care providers. For instance, people with arthritis, who receive advice to perform physical activity, demonstrate greater participation (52). However, compared with their White counterparts, Black patients with arthritis receive less advice on physical activity (53), which might explain the racial discrepancy. In addition to an absence of encouragement, Black people also experience threatening scenarios in American society. For instance, when riding a bicycle, Black people are more likely to be the victim of accidents or ticketed by police, and to be a victim of violent crime when walking or jogging, compared with White people (54). These racial disparities in safety might contribute to a lower tendency to be physically active in outdoor settings that are cost-free, such as walking on sidewalks, biking on streets, and trekking on trails.

Finally, our hypotheses pertaining to HR-QOL were validated by the conceptual model. In addition to the proximal behavioral determinant (physical activity), racial disparities also found in biopsychosocial predictors (pain and depression) explained why Black people experience lower HR-QOL. These variables form as pillars of the multidimensional outcome and signify both the importance and challenge of addressing disparities in determinants for leveling asymmetrical differences in HR-QOL.

Strengths and limitations

Our study has strengths that advance the current literature along with respective limitations. We proposed a conceptual model that included biopsychosocial predictors and behavioral determinants that explained why Black people with knee OA experience lower HR-QOL compared with White people. To the best of our knowledge, ours is the first study to employ a conceptual model to provide greater insight into racial health disparities among people with knee OA. Hypotheses that are tested using theory or conceptual framework yield more robust findings, as the effect sizes are in scope of other relevant determinants (55). Additionally, the large sample size that includes longitudinal data collected from multiple study sites, which include commonly used validated measures, are all strength markers of the study. Limitations of this study include the absence of behavior-related physical activity determinants that could provide additional insight and opportunity for investigation, and if there were racial disparities among these determinants, such barriers, motivations, and self-efficacy toward participating in physical activity. Additionally, it is important to note that several individual-level factors can affect the model constructs, such as BMI. However, BMI plays a complex role among people with knee OA as it would likely directly predict pain and moderate the effects between pain and depression, and between depression and physical activity. The PROCESS macro currently does not include a model that accounts for these effects. Nonetheless, we recognize the importance of BMI, and future interventions should focus on helping patients with knee OA obtain a healthy BMI level. Future large-scale observational studies are needed to assess physical activity determinants from a behavior theory, such as the Health Belief Model or Social Cognitive Theory.

Conclusions

The findings highlight racial health disparities that exist in psychological, behavioral, and wellbeing variables among people with knee OA, to the extent to which Black people experienced worse pain, depression, and HR-QOL while they had lower levels of physical activity compared with their White counterparts. This pattern of disparities remained the same throughout the study timeline. The serial mediated effects further explained the process of relationship between races with pain, depression, and physical activity as potential contributors to HR-QOL among patients with knee OA. In conjunction with the literature (47), the present findings help identify patterns of health disparity in pain, depression, and physical activity related to knee OA, that might be associated with previously observed disparity in knee OA treatment. For instance, studies have demonstrated that people with knee OA who are Black are less likely to undergo total knee arthroplasty, which might lead to the presence of health disparities (56).

Because physical activity and exercise programs have been shown to improve pain, depression, and quality of life among knee OA patients (11–13), research is needed to design community-based physical activity programs that account for racial and cultural differences to provide a safe and motivating climate (14). For instance, among Black populations, churches and community centers have been shown to promote physical activity effectively (57). Finally, programs found to be effective for training health care providers and developing community-based physical activity programs to reduce racial disparities should be advocated for policies that promote equitable health in the United States.

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Tables

Table 1. Demographic Characteristics of the Sample, Osteoarthritis Initiative, 2006–2014[a]

Variable	White (n = 2,088)	Black (n = 515)	*P* value (statistical test value)[b]
Age, mean (SD) [range], y	68.6 (9.0) [51–85]	65.9 (8.4) [50–85]	<.001 (*F* = 26.7)
Body mass index, mean (SD) [range], kg/m^2	28.9 (4.6) [16.9–46.8]	32.2 (4.8) [20.3–48.7]	<.001 (*F* = 202.0)
Sex			
Male	938 (44.9)	149 (28.9)	<.001 (χ^2 = 43.4)
Female	1,150 (55.1)	366 (71.1)	
Income, $			
<10,000	40 (2.0)	55 (12.1)	<.001 (χ^2 = 207.7)
10,000–24,999	181 (9.2)	89 (19.6)	
25,000–49,999	500 (25.5)	158 (34.7)	
50,000–99,999	754 (38.5)	119 (26.2)	
>100,000	483 (24.7)	34 (7.5)	
Education			
High school graduate	258 (12.8)	106 (21.2)	<.001 (χ^2 = 173.2)
Some college	482 (23.9)	190 (37.9)	
College graduate	477 (23.6)	56 (11.2)	
Some graduate school	191 (9.4)	28 (5.6)	
Graduate degree	612 (30.3)	70 (14.0)	
Employment			
Works for pay	1,207 (58.2)	304 (59.7)	<.001 (χ^2 = 59.9)
Unpaid work for family business	28 (1.3)	8 (1.6)	
Not working for health reasons	79 (3.8)	60 (11.8)	
Not working for other reasons	761 (36.7)	137 (26.9)	

[a] Values are no. (%) unless otherwise indicated. Values may not sum to total because of missing data.
[b] One-way analysis of variance was used for continuous variables, and the χ^2 test was used for categorical variables.

Table 2. Participant Scores for Outcome Variables at Baseline and Week 96, by Race, Osteoarthritis Initiative, 2006–2014

Outcome variable	White	Black	ANOVA *P* value (*F*)
	Mean (SD) [range]		
Baseline			
Pain	4.6 (5.1) [0–33]	10.0 (7.7) [0–39]	<.001 (365.3)
Depression	24.8 (5.3) [20–58]	26.5 (7.4) [20–61]	<.001 (29.3)
Physical activity (PASE)	157.3 (78.8) [0–465]	144.8 (87.0) [0–504]	.002 (9.8)
Quality of life	47.1 (6.0) [16–56]	42.4 (8.7) [14–55]	<.001 (205.7)
Follow-up			
Pain	4.5 (5.1) [0–28]	8.9 (8.4) [0–36]	<.001 (167.1)
Depression	25.9 (5.8) [20–64]	26.3 (6.1) [20–68]	<.001 (22.1)
Physical activity (PASE)	148.2 (81.1) [0–570]	128.9 (82.0) [0–429]	<.001 (16.4)
Quality of life	45.7 (7.0) [16–56]	42.1 (9.3) [16–56]	<.001 (67.6)

Abbreviations: ANOVA, analysis of variance; PASE, Physical Activity Scale for the Elderly.

Table 3. Zero-Order Correlations Among Study Variables, Osteoarthritis Initiative, 2006–2014[a]

Construct	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Race									
Baseline									
2. Pain	.352[b]	—							
3. Depression	.111[b]	.253[b]	—						
4. Physical Activity	−.062[b]	−.035	−.012	—					
5. Quality of Life	−.272[b]	−.546[b]	−.657[b]	.136[b]	—				
Follow-up									
6. Pain	.276[b]	.573[b]	.269[b]	−.009	−.436[b]	—			
7. Depression	.109[b]	.212[b]	.551[b]	−.007	−.493[b]	.280[b]	—		
8. Physical Activity	−.093[b]	−.046[c]	−.040	.515[b]	.139[b]	−.055[c]	−.081[b]	—	
9. Quality of Life	−.182[b]	−.378[b]	−.447[b]	.126[b]	.640[b]	−.508[b]	−.623[b]	.256[b]	—

[a] Race coded as 1 = White, 2 = Black.
[b] $P < .01$.
[c] $P < .05$.

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ORIGINAL RESEARCH

Physical Activity Among Rural Men: Barriers and Preferences

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Summary

What is already known on this topic?

Rural men are underrepresented in physical activity interventions and are at higher disease risk than urban men.

What is added by this report?

We surveyed a sample of rural men to determine barriers to physical activity and preferences for interventions.

What are the implications for public health practice?

A systematic approach and a clear model of development are needed to tailor physical activity interventions to the special needs of rural men.

Abstract

Introduction
Physical activity positively affects health. Although 94% of Americans know the health benefits of regular physical activity, more than 75% do not achieve recommended levels. The objective of our study was to identify and define the key components of a physical activity intervention tailored to rural American men.

Methods
We recruited rural men (N = 447) via Amazon’s Mechanical Turk online platform to complete a needs assessment survey focused on their interest in a physical activity intervention, preferred intervention features, and potential intervention objectives. Data were summarized by using descriptive statistics. A cumulative logistic regression model examined associations between the men’s perceived importance of physical activity to health and their interest in a physical activity intervention.

Results
Almost all participants (97.7%) rated physical activity as “at least somewhat important” to their health, and 83.9% indicated they would be “at least somewhat interested” in participating in a physical activity intervention. On a scale of 1 (not at all a barrier) to 5 (very much a barrier), motivation (mean 3.4; 95% CI, 3.3–3.5), cold weather (mean, 3.4; 95% CI, 3.3–3.5), and tiredness (mean, 3.3; 95% CI, 3.2–3.4) were rated the biggest barriers to physical activity. Becoming fitter (54.1%) was the top reason for joining a physical activity program. Preferred delivery channels for receiving an intervention were mobile application (ranked from 1 being the most preferred and 9 being the least preferred: mean, 2.8; 95% CI, 2.70–3.09) and e-mail (mean, 4.2; 95% CI, 3.92–4.36). Rural men preferred interventions that taught them how to exercise and that could be done from home.

Conclusion
Our findings suggest US men in rural areas are receptive to physical activity programs. A systematic approach and a clear model of development are needed to tailor future physical activity interventions to the special needs of rural men.

Introduction

Physical activity positively affects health (1). An estimated 94% of Americans know the health benefits of regular physical activity (2), but more than 75% do not achieve recommended activity levels (3). Almost 25% of Americans who do not meet recommended levels report not participating in any leisure-time physical activity (3). These findings suggest that information alone is not enough to make a healthy behavior change (4) and that interventions are needed that promote more than awareness of the benefits of physical activity.

The 23 million US men who live in rural areas are an understudied population at increased risk for inactivity-related chronic conditions. For example, rural men have a 19% higher age-adjusted death rate than urban men and a 39% higher rate than rural women (5). They also have higher rates of inactivity-related chronic conditions, such as cardiovascular disease (6), diabetes (7), cancer (8), and obesity (3). These differences may be due in part to observed differences in physical activity rates because fewer rural men report meeting physical activity guidelines compared with urban men (9). Although increasing physical activity rates among rural men could reduce the gap in urban and rural health disparities (1), rural men are underrepresented in physical activity interventions (10,11). Behavioral interventions are needed to increase physical activity in this population to improve their health outcomes.

The Obesity-Related Behavioral Intervention Trials (ORBIT) model (12) was designed by a working group from the National Institutes of Health (including the National Cancer Institute and the National Heart, Lung, and Blood Institute) to facilitate and standardize the development of behavioral interventions. The ORBIT model emphasizes understanding the needs of a study population before tailoring an intervention to that population's needs. Such a systematic approach is more effective than nonsystematic approaches. However, little information is currently available on the physical activity-related needs of American rural men. Therefore, the primary aim of our study was to identify the key components and objectives of a physical activity intervention tailored to the unique needs of rural US men to inform the development of future interventions directed at them.

Methods

Participants

We recruited a nationwide sample of rural residents (N = 447), who identified through a 2-item eligibility screener as male and living in a rural area. We defined rural according to the US Department of Agriculture's definition as a town with fewer than 2,500 residents or an area outside a town (13).

Study participants were recruited from among US participants in Amazon's Mechanical Turk (MTurk), an online crowdsourcing platform. A full description of MTurk is available on their website (mturk.com). We advertised our study on MTurk in broad terms as "A study on physical activity" so that MTurk workers (ie, users who sign up and get paid to complete small tasks) did not know our eligibility criteria (men residing in rural areas) before answering gender and residence (rural or urban) questions. Interested workers were directed to an online survey hosted on the Qualtrics software platform (Qualtrics XM).

We obtained informed consent from all participants before they completed our survey. To be included in the final data analysis, participants had to respond correctly to an attention-check question to ensure data quality. Less than 5% of participant data were missing (ie, missed questions or nonresponses). Settings were configured to prevent people from retaking the survey, using automated systems, or completing the survey too quickly. The Social Sciences Institutional Review Board at the University of Iowa approved all study procedures.

Research design

The first phase of the ORBIT model focuses on identifying appropriate intervention techniques (ie, reasons for joining, delivery methods, program features) and potential participants in the intervention (14). Consistent with the ORBIT model, our study used a cross-sectional design with participants completing a single survey that addressed 3 main areas: 1) interest in a physical activity intervention, 2) preferred intervention features, and 3) potential intervention goals. The survey was modeled after Cadmus-Bertram's 2019 mail-based survey, which asked about physical activity barriers and facilitators among rural women residing in Wisconsin (15). On completion of the survey, participants were given a completion code to enter on MTurk to receive $2.00.

Demographics

Participants were asked to report their age, ethnicity, race, education level, income, marital status, number of children under the age of 18 in the household, perceived health status (excellent, very good, good, fair, poor), employment status (full-time; part-time; unemployed, looking for work; unemployed, not looking for work; full-time or part-time student; disabled; retired), occupation, and a basic description of physical activity the occupation entailed (mostly sitting or standing, mostly walking, mostly heavy labor or physically demanding work).

Interest in a physical activity intervention

Participants ranked how important they believed physical activity was for good health on a 5-point Likert scale from 1 (not at all important) to 5 (very important). Participants also rated on a 5-point Likert scale from 1 (not at all interested) to 5 (very interested) how interested they would be in a program that could help them be more active.

Preferred intervention techniques

Access to and use of computer technology were assessed to determine how best to deliver future interventions to rural men. Participants reported their access to the internet (eg, broadband, dial-up) and to cellular telephone service (smartphone, traditional [does only SMS texting and telephone calls], or no cellular telephone). Participants answered yes or no to a question that asked what they used their telephone for (calls, internet, applications). Participants also reported their use of wearable physical activity trackers (eg, Fitbits, pedometers). Participants answered yes or no to the question about whether, to be physically active, they had used or were willing to try various online resources (eg, exercise videos), internet-connected devices (eg, Peloton spin bikes), or telehealth services.

We then assessed facilitators to physical activity and participation in interventions by asking participants about their preferred types of exercise. We also asked about their preferred delivery method for a physical activity program with a 9-item list of delivery methods: video conferencing, telephone, group training, in-person one-on-one, mail, social media, text messaging, email, or mobile app. Environmental facilitators and barriers were assessed by asking what facilities were currently available and whether they used those facilities. The survey also asked about reasons for joining a physical activity program and whom they might be interested in being active with (eg, significant others, friends, coworkers). Participants selected whether certain program features (eg, "can be done from home," "men only") were required to partake in the program or were barriers to participating in a program.

Potential intervention objectives

Addressing common barriers to physical activity is one way for an intervention to promote physical activity. To understand the barriers rural men perceive to physical activity, participants were asked to rank on a Likert scale from 1 (not at all a barrier) to 5 (very much a barrier) the degree to which 25 commonly cited barriers to physical activity interfered with their physical activity behavior (eg, lack of motivation, weather, fear of exposure to COVID-19) (15).

Statistical analysis

To generalize to the 23 million rural men in the US we needed an estimated sample size of at least 385 participants to have a 5% margin of error using 95% CIs. To summarize data we used descriptive statistics, including mean and standard deviation for continuous variables and frequencies and percentages for categorical variables. We used the VGAM (Vector Generalized Linear and Additive Models) package in R (16) to analyze the multivariable associations of the importance of physical activity to health and the likelihood of being interested in a physical activity intervention by a cumulative logistic regression model. Data analysis was performed by using R (R Foundation for Statistical Computing).

Results

Demographics

A total of 8,182 MTurk workers completed our 2-item screener. Of these, 4,535 did not identify as male: 4,402 responded female, 61 responded nonbinary, 53 preferred not to answer, and 19 gave no response. Of the remaining male respondents, 3,039 did not live in a rural community. Another 161 who took the survey and otherwise qualified did not pass the attention check. After screening out those who did not meet our eligibility criteria, 447 rural men were included in our study.

Participants were mostly White (85.5%), non-Hispanic (84.6%), highly educated (79.3% had a college degree), and married (72.5%) (Table 1) with an average age of 34.7 years (SD, 11.7). By using IP addresses to determine geographic region as defined by the US Census Bureau, we determined that 125 (28%) participants were from the Midwest, 48 (11%) from the Northeast, 139 (31%) from the South, and 108 (24%) from the West. We were unable to identify 27 participants by IP address; these respondents were included as "Unknown/unsure" of location.

Interest in a physical activity intervention

A total of 97.7% of rural men in our sample viewed exercise as at least somewhat important to their health, and 40.3% reported it as very important. Overall, most reported interest (83.9%) in joining a physical activity program; 23.9% were very interested, 33.6% were interested, and 26.4% were somewhat interested. The more important that men viewed exercise to be to their health, the more likely they were to be at least somewhat interested in a physical activity program. Each category increase for importance (ie, somewhat important to important) was associated with 1.38 times (odds ratio [OR] = 1.38; 95% CI, 1.13–1.68) greater odds of being more interested in a physical activity program (ie, greater odds in very interested compared with interested, or of interested compared with somewhat interested). Breaking out responses by demographic characteristics, we found substantial variation in levels of interest (Appendix).

Preferred intervention techniques

Most rural men in our sample (77.6%) reported using broadband and 11.9% used only their cellular telephones for internet access. For cellular telephone service, 86.1% used smartphones, and 11.0% used a traditional cellular telephone. The remaining participants did not use a cellular telephone (2.9%). For smartphone users, common uses were texting (99.7%), photographs (96.3%), email (95.0%), internet (92.5%), social media (91.9%), calendar (83.0%), and video conferencing (68.2%).

For remote resources, more than half of men in our sample (60.1%) currently used exercise smartphone applications or had used them in the past, and 52.2% had used exercise training videos (eg, P90x, Beach Body). Respondents had less experience with online exercise classes (49.3% currently used or had used them previously), internet-connected devices (44.9%; eg, Peloton), pedometers (40.5%), smartwatches (40.3%), and Fitbits (38.6%). Among the men who reported not using these systems in the past, 68.0% were interested in trying online exercise classes, 62.1% in internet-connected devices, 59.1% in smartphone exercise applications, 49.2% in exercise training videos, 48.3% in smartwatches, 45.3% in Fitbits, 44.8% in digital scales, and 42.9% in pedometers.

Although 84% of participants reported that parks were the most available facility for physical activity, 68.9% said they used the sidewalks around their home (Figure 1). For social support, participants reported being active with friends (64.2%), children (50.1%), or a significant other (49.2%). Fewer men were interested in being active with other community members (31.3%), coworkers (30.2%), family (28.2%), exercise groups (23.5%), pets (19.0%), and other community members (2.9%).

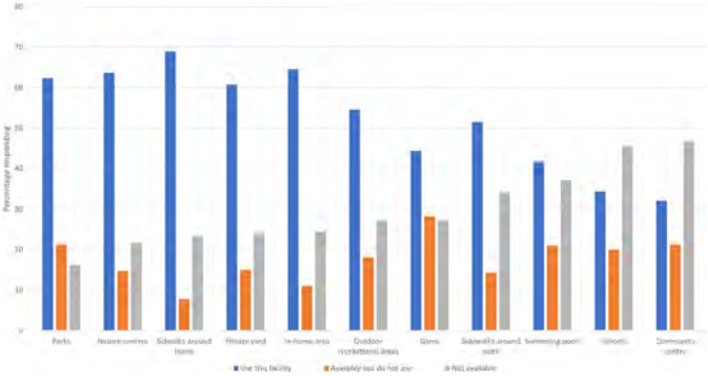

Figure 1. Facilities or locations for physical activity available to a nationwide sample (N = 447) of rural US men and percentage who used them.

Respondents reported that the following were 3 of their favorite types of physical activity: walking (64.4%), running (51.7%), and biking (40.7%). Men who said they were interested in a physical activity program gave the following as their reasons: to be more physically fit (54.1%), to get more energy (52.6%), and to improve mood or mental health (45.2%). When asked to rank how they would prefer to receive a physical activity program, the highest-ranked of the 9 options were mobile applications (mean, 2.8; 95% CI, 2.70–3.09), e-mail (mean, 4.2; 95% CI, 3.92–4.36), social media (mean, 4.6; 95% CI, 4.47–4.89), and text messaging (mean, 4.6; 95% CI, 4.38–4.78.). Video conferencing (mean, 6.7; 95% CI, 6.51-7.00), telephone (mean, 6.0; 95% CI, 5.85–6.23), and in-person (mean, 5.5; 95% CI, 5.22–5.68) were ranked the lowest.

When asked which program features they preferred in a physical activity program, responses were instructions on how to exercise (81.0% of participants), exercises that can be done from home (78.1%), and programs that focus on incorporating physical activity into a daily routine (74.2%) (Figure 2).

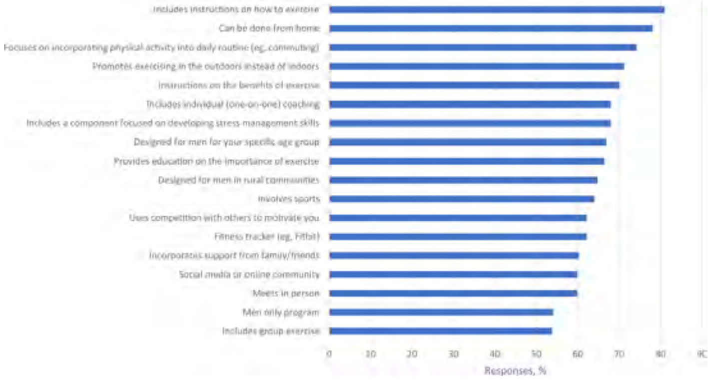

Figure 2. Selected features preferred or required in a physical activity program by a nationwide sample (N = 447) of rural US men.

Potential intervention targets

The most challenging barriers to physical activity among rural men, rated on a scale of 1 (not at all a barrier) to 5 (very much a barrier), were motivation (mean, 3.4; 95% CI, 3.3–3.5), cold weather (mean, 3.4; 95% CI, 3.3–3.5), and tiredness (mean, 3.3; 95% CI, 3.2–3.4) (Table 2).

Regional and location differences

We saw no differences for any measured variables when comparing men who reported living in a small town versus those who reported living outside of a town. However, when comparing variables of interest by rural geographic regions (ie, Northeast, South, Midwest, West) in a linear regression model, we observed a significant difference in reported barriers to physical activity by region (Table 2). Although the order of barriers was mostly consistent by region, rural men in the West rated greater barriers to physical activity than men in other regions. Fear for safety because of COVID-19 was rated as the strongest barrier among men in the West.

Discussion

Interest in a physical activity intervention

Despite under-representation of US rural men in physical activity interventions, our nationwide sample reported being interested in receiving them. Previous interventions in rural communities have not been tailored to rural men (10,11). Although these men are interested in a physical activity program, the lack of success in previous interventions suggests a need for tailored interventions.

Rural men reported gaining fitness, increasing energy, and improving mental health as their top reasons for joining a physical activity program. In contrast, previous research showed that rural women ranked improved health, losing weight, and increased energy as their top reasons (15). Interventions among rural men that focused on weight loss have been successful in other studies (17), but how marketing may affect recruitment, including sampling bias, is unclear. Our results suggest promotional and recruitment materials that emphasize outcomes of fitness and increased energy instead of weight loss may appeal to more men. Future studies are needed on the effects of different marketing approaches on recruitment and retention. Intervention planners should consider their study population and the effect of marketing on that population's perceptions of an intervention.

Preferred intervention techniques

Men in our study reported a strong preference for remote delivery interventions, and mobile telephone applications were the highest-rated delivery method. This contrasts with findings among rural women who rated in-person meetings as their preferred delivery method (15). This difference may be due to men's having a negative perception of certain exercise routines (18), resulting in a desire for privacy. Alternatively, this apparent preference may be a result of sampling differences. Cadmus-Bertram (15) collected data from mail surveys, whereas we used an online system. As a result, our sample may have included more technologically inclined men. In addition, the increased use of remote technology resulting from the COVID-19 pandemic could partially explain the differences. Our study was conducted during the pandemic and the Cadmus-Bertram study was conducted before the pandemic. In-person sessions have been used successfully in urban populations (19), but access to such sessions may be difficult for rural men given distances (20). Smartphones have been found to be an acceptable and feasible delivery method for other health interventions among rural men (17), adding further support for their use.

Our findings suggest that a physical activity intervention tailored to rural men should allow participation from home, provide specific instructions on how to exercise as opposed to the benefits of exercise, and teach how to incorporate exercise into a daily routine. Similarly, previous studies have reported that men desire straightforward information and prefer more purposeful physical activity such as active commuting, as opposed to planned exercise (19,20).

We found that the top barriers to physical activity among rural men were low motivation, cold weather, and tiredness. The lack of facilities was not listed as a top barrier is notable. Previous studies reported a lack of facilities and long commutes as major barriers among rural populations (21,22). Rural men may believe in-home resources are sufficient and may not need traditional exercise facilities as long as they have access to remotely delivered programs, but this possibility requires additional research.

Future directions

Although our findings suggest that rural men in the US are interested in participating in physical activity interventions and that their preference for remote delivery methods removes the barrier of facility availability, future studies are needed to develop and test physical activity interventions tailored to their needs and preferences. Given the heterogeneity of the rural male population, more work may be needed to apply these findings to specific groups (eg, men in various geographic regions). We observed differences in the strength of physical activity barriers when comparing rural men by geographic region. Interventions directed at rural men in Western regions may need to be designed differently to address that population's strongest barriers, such as fear of exposure to COVID-19.

Strengths and limitations

Our study has several strengths. It is the first study, to our knowledge, of what types of physical activity intervention rural US men want. The use of MTurk to recruit a nationwide sample of participants is novel and directly supported our goal of understanding rural men across all geographic regions.

Our study had several limitations. Although MTurk has been shown to generate data representative of the general population (23), our sample of MTurk workers could be more technologically savvy and more educated than the general population of rural men. The reported broadband access and use among our sample was similar to data collected among rural men by the Pew Research Center (24). However, our sample was more educated than the national average of rural men: 79.3% of our sample had a college degree compared with the national average of approximately 20% (25). Also, to ensure data quality, we followed recommended best practices (26) such as including only participants who passed the attention check and changing the survey settings to prevent automated responses and too-quick data entry. Sampling bias could also have been a limitation. Our study was advertised as a "survey on physical activity." MTurk workers interested in physical activity may have been more likely to volunteer to take the survey. Because of the large heterogeneity of rural men, such as various cultures and environmental factors, our results may not be generalizable to all groups, particularly rural men with less education and men from minority groups. More research is needed to confirm the preferences we observed by studying specific subgroups of rural men, particularly those who were not well represented in our sample (ie, men in racial and ethnic minority groups and men with less education). Future studies could use more traditional methods to confirm our findings in specific populations, such as focus groups, interviews, and mail, telephone, or email surveys.

Conclusion

Our findings suggest rural men are interested in physical activity programs despite their low representation in published studies of physical activity interventions. Rural men reported a preference for remotely delivered programs that could be carried out at home and as part of daily routines and that included straightforward demonstrations of physical activity. Further research is needed to determine whether physical activity interventions that incorporate our findings are effective for promoting physical activity behavior change among rural men.

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Tables

Table 1. Demographic Characteristics Reported by a Nationwide Sample (N = 447) of Rural US Men

Characteristic	Percentage
Ethnicity	
Not Hispanic or Latino	84.6
Hispanic or Latino	14.5
Race	
Black/African American	6.7
White	85.5
Education	
High school graduate	7.6
Some college	12.1
Trade, technical, or vocational training	2.9
College graduate	40.0
Some post-graduate work	8.9
Post-graduate degree	27.5
Annual income, $	
<24,999	12.1
25,000–49,999	22.6
50,000–74,999	22.4
75,000–99,999	25.3
100,000–149,999	14.6
>150,000	2.9
No. of children	
0	31.8
1	33.8
2	29.3
≥3	4.7
Marital status	
Married	72.5
Never married	22.8
Divorced	2.2
Self- reported health status	
Excellent	40.3
Very good	34.3
Good	24.7
Poor	0.7
Employment status	
Full-time	79.2
Looking for work	7.2

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Table 1. Demographic Characteristics Reported by a Nationwide Sample (N = 447) of Rural US Men

Characteristic	Percentage
Student	3.4
Retired	3.4
Occupational activity	
Mostly sitting or standing	62.2
Mostly walking	19.9
Mostly heavy labor or physical demanding work	14.5

Table 2. Barriers to Physical Activity Reported by a Nationwide Sample (N = 447) of Rural US Men, by Region[a]

Barrier	All	Region			
		Northeast (n = 48)	Midwest (n = 125)	South (n = 139)	West (n = 108)
Motivation	3.4 (3.3–3.5)	3.3 (2.9–3.7)	3.3 (3.1–3.5)	3.5 (3.3–3.7)	3.5 (3.2–3.7)
Cold weather	3.4 (3.3–3.5)	2.9 (2.6–3.3)[b]	3.3 (3.1–3.5)	3.5 (3.3–3.7)	3.5 (3.3–3.7)
Tiredness	3.3 (3.2–3.4)	3.2 (2.8–3.5)	3.2 (3.0–3.4)	3.4 (3.2–3.6)	3.3 (3.1–3.5)
Hard to find time because of housework	3.2 (3.1–3.3)	3.3 (2.9–3.6)	3.0 (2.7–3.2)	3.2 (3.0–3.4)	3.4 (3.2–3.6)
Hard to find time because of job	3.2 (3.0–3.3)	3.0 (2.6–3.4)	3.0 (2.7–3.2)	3.2 (3.0–3.5)	3.3 (3.1–3.5)
Weather issues in the heat	3.1 (3.0–3.2)	2.6 (2.1–3.0)[b]	2.8 (2.6–3.0)[b]	3.2 (3.0–3.5)	3.4 (3.2–3.6)
Fear for safety (COVID-19)	3.1 (3.0–3.2)	2.7 (2.2–3.1)	2.8 (2.5–3.1)	3.1 (2.9–3.4)	3.6 (3.4–3.8)[b]
Short daylight hours in the winter	3.0 (2.8–3.1)	2.6 (2.2–3.0)	2.9 (2.6–3.1)	2.9 (2.6–3.1)	3.4 (3.2–3.6)[b]
No convenient places to exercise indoors	3.0 (2.8–3.1)	2.5 (2.1–3.0)	2.8 (2.6–3.1)	3.0 (2.7–3.2)	3.3 (3.1–3.5)[b]
Health problems make it hard to be active	2.9 (2.7–3.0)	2.4 (2.0–2.9)	2.7 (2.5–3.0)	2.9 (2.7–3.2)	3.2 (3.0–3.5)
Cost	2.9 (2.7–3.0)	2.2 (1.8–2.6)	2.7 (2.4–3.0)	2.9 (2.6–3.1)	3.4 (3.2–3.6)[b]
Dislike physical activity	2.8 (2.7–3.0)	2.5 (2.1–2.9)	2.8 (2.5–3.0)	2.8 (2.5–3.0)	3.2 (3.0–3.5)[b]
No convenient place to exercise outdoors	2.8 (2.7–3.0)	2.4 (2.0–2.8)	2.8 (2.5–3.0)	2.8 (2.6–3.0)	3.2 (3.0–3.4)[b]
I don't have anyone to exercise with	2.8 (2.7–2.9)	2.6 (2.2–3.0)	2.5 (2.3–2.8)	2.8 (2.6–3.0)	3.2 (2.9–3.4)[b]
Unsure how to get started	2.8 (2.6–2.9)	2.4 (2.0–2.7)	2.7 (2.4–2.9)	2.7 (2.5–3.0)	3.2 (3.0–3.4)[b]
Fear of injury	2.7 (2.6–2.9)	2.2 (1.8–2.7)	2.5 (2.2–2.7)	2.8 (2.5–3.0)	3.4 (3.1–3.6)[b]
Lack of support from family or spouse	2.7 (2.6–2.8)	2.1 (1.7–2.5)[b]	2.5 (2.3–2.8)[b]	2.8 (2.6–3.0)[b]	3.1 (2.9–3. 4)[b]
Hard to find time due to caregiving for a child	2.7 (2.6–2.8)	2.5 (2.0–2.9)	2.6 (2.4–2.9)	2.6 (2.3–2.8)	3.2 (3.0–3.4)[b]
Fear for safety because of traffic	2.7 (2.5–2.8)	2.1 (1.7–2.5)	2.5 (2.2–2.8)	2.7 (2.5–3.0)	3.3 (3.1–3.5)[b]
Fear for safety because of crime	2.6 (2.5–2.8)	1.9 (1.5–2.3)[b]	2.4 (2.2–2.7)[b]	2.7 (2.4–3.0)[b]	3.3 (3.0–3.5)[b]
Not sure of physical activity benefits	2.6 (2.5–2.7)	2.0 (1.6–2.4)	2.4 (2.2–2.7)	2.6 (2.4–2.9)	3.1 (2.9–3.3)[b]
Community is not supportive of physical activity	2.6 (2.4–2.7)	2.0 (1.6–2.4)	2.4 (2.2–2.7)	2.6 (2.3–2.8)	3.2 (3.0–3.4)[b]
Fear for safety because of wild animals	2.5 (2.4–2.6)	2.0 (1.6–2.5)	2.3 (2.1–2.6)	2.5 (2.2–2.7)	3.1 (2.9–3.3)[b]
Hard to find time because of adult caregiving	2.5 (2.4–2.6)	2.0 (1.6–2.4)	2.3 (2.1–2.6)	2.5 (2.2–2.7)	3.1 (2.9–3.4)[b]

[a] Values are mean (95% CI). Rated on a scale of 1 (not at all a barrier) to 5 (very much a barrier).
[b] Significant difference (*P* < .05) detected by regression model.

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Appendix

Appendix. Supplemental Table. Interest Level in a Physical Activity Program Reported by a Nationwide Sample (N = 447) of Rural US Men, by Demographic Characteristics[a]

Demographic characteristic	All (N = 447)	Not at all interested (n = 23)	Not very interested (n = 49)	Somewhat interested (n = 118)	Interested (n = 150)	Very interested (n = 107)
Hispanic						
No	84.6	95.7	87.8	85.6	80.7	85.0
Yes	14.5	4.3	10.2	12.7	18.7	15.0
Race						
Black or African American	6.7	4.3	6.1	4.2	8.7	7.5
White	85.5	91.3	89.8	86.4	82.0	86.0
Education						
High school graduate	7.6	30.4	12.2	7.6	3.3	6.5
Some college	12.1	30.4	18.4	16.9	8.7	4.7
Trade, technical, or vocational training	2.9	4.3	8.2	4.2	1.3	0.9
College graduate	40.0	26.1	36.7	40.7	42.7	40.2
Some postgraduate work	8.9	4.3	4.1	10.2	10.0	9.3
Postgraduate degree	27.5	4.3	18.4	19.5	34.0	36.4
Annual income, $						
<24,999	12.1	17.4	12.2	8.5	12.0	15.0
25,000–49,999	22.6	47.8	36.7	22.0	18.0	17.8
50,000–74,999	22.4	26.1	26.5	25.4	22.7	15.9
75,000–99,999	25.3	4.3	12.2	28.8	28.7	27.1
100,000–149,999	14.6	4.3	8.2	14.4	15.3	18.7
≥150,000	2.9	0	4.1	0.8	3.3	4.7
No. of children in household						
0	31.8	69.6	49.0	41.5	20.7	20.6
1	33.8	13.0	18.4	36.4	36.7	38.3
2	29.3	13.0	16.3	21.2	38.7	34.6
≥3	4.7	4.3	16.3	0.8	3.3	5.6
Marital status						
Married	72.5	39.1	67.3	66.1	81.3	76.6
Never married	22.8	56.5	28.6	31.4	14.0	15.9
Divorced	2.2	4.3	4.1	1.7	2.7	0.9
Self-reported health status						
Excellent	40.3	17.4	8.2	33.9	44.7	49.5
Very good	34.3	39.1	42.9	29.7	30.7	29.9
Good	24.7	26.1	32.7	25.4	22.7	15.9
Poor	0.7	17.4	14.3	9.3	1.3	1.9
Employment status						

[a] Values are percentage. Percentages may not add to 100 because of rounding.

(continued on next page)

(continued)

Appendix. Supplemental Table. Interest Level in a Physical Activity Program Reported by a Nationwide Sample (N = 447) of Rural US Men, by Demographic Characteristics[a]

Demographic characteristic	All (N = 447)	Not at all interested (n = 23)	Not very interested (n = 49)	Somewhat interested (n = 118)	Interested (n = 150)	Very interested (n = 107)
Fulltime	79.2	52.2	55.1	80.5	85.3	81.3
Looking for work	7.2	13.0	6.1	1.7	4.0	5.6
Student	3.4	0	2.0	1.7	2.0	0
Retired	3.4	17.4	14.3	2.5	0	0.9
Occupational activity						
Mostly sitting or standing	62.2	47.8	53.1	66.1	64.7	61.7
Mostly walking	19.9	4.3	26.5	21.2	20.0	18.7
Mostly heavy labor or physically demanding work	14.5	30.4	10.2	10.2	13.3	19.6

[a] Values are percentage. Percentages may not add to 100 because of rounding.

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ORIGINAL RESEARCH

Dynamic Patterns and Modeling of Early COVID-19 Transmission by Dynamic Mode Decomposition

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PEER REVIEWED

Summary

What is already known on this topic?

People who have COVID-19 but are asymptomatic can transmit the SARS-CoV-2 virus, making it difficult to accurately model the dynamic spread of the infection.

What is added by this report?

We used dynamic mode decomposition to show that certain areas in the US shared similar trends and similar spatiotemporal transmission patterns of COVID-19.

What are the implications for public health practice?

Our findings can contribute to a better understanding of the characteristics of early COVID-19 transmission and provide decision makers with timely and accurate information to respond to the pandemic and future public health emergencies.

Abstract

Introduction

Understanding the transmission patterns and dynamics of COVID-19 is critical to effective monitoring, intervention, and control for future pandemics. The aim of this study was to investigate the spatial and temporal characteristics of COVID-19 transmission during the early stage of the outbreak in the US, with the goal of informing future responses to similar outbreaks.

Methods

We used dynamic mode decomposition (DMD) and national data on COVID-19 cases (April 6, 2020–October 9, 2020) to model the spread of COVID-19 in the US as a dynamic system. DMD can decompose the complex evolution of disease cases into linear combinations of simple spatial patterns or structures (modes) with time-dependent mode amplitudes (coefficients). The modes reveal the hidden dynamic behaviors of the data. We identified geographic patterns of COVID-19 spread and quantified time-dependent changes in COVID-19 cases during the study period.

Results

The magnitude analysis from the dominant mode in DMD showed that California, Louisiana, Kansas, Georgia, and Texas had higher numbers of COVID-19 cases than other areas during the study period. States such as Arizona, Florida, Georgia, Massachusetts, New York, and Texas showed simultaneous increases in the number of COVID-19 cases, consistent with data from the Centers for Disease Control and Prevention.

Conclusion

Results from DMD analysis indicate that certain areas in the US shared similar trends and similar spatiotemporal transmission patterns of COVID-19. These results provide valuable insights into the spread of COVID-19 and can inform policy makers and public health authorities in designing and implementing mitigation interventions.

Introduction

COVID-19 has caused millions of deaths and is a major public health burden worldwide. The rapid increase in COVID-19 cases can be attributed to various factors, such as the distinctive spike protein of SARS-CoV-2, the virus that causes COVID-19; the virus' exponential growth rate, high reproduction number (R0), and high mutation rate; and poorly ventilated indoor settings (1-4). In addition, asymptomatic people may transmit COVID-19, making it difficult to accurately model the dynamic spread of the disease (5). Because of the magnitude and severity of outcomes associated with COVID-19, investigation of the coherent spatiotemporal dynamics of COVID-19 transmission is crucial (6,7).

Dynamic mode decomposition (DMD) is an equation-free method originally developed in the field of fluid dynamics to investigate coherent spatiotemporal modes. DMD can efficiently reveal the hidden structures of spatiotemporal dynamics from existing data without the requirement of previous assumptions of the studied dataset (8,9). It is a top-down data-driven model that discovers the eigenvectors and eigenvalues of a mapping matrix that relates 2 different snapshots of given data. DMD has limited applicability for strong nonlinear problems (eg, public health interventions for vaccine coverage and herd immunity that may require nonlinear modeling and feedback mechanisms) and long-range predictions (eg, prediction of obesity prevalence in a city for the next 20 years with data only from the most recent year); however, this limited applicability does not affect short-range predictions or studies on the cumulative number of disease cases. Before the COVID-19 pandemic, DMD had been used to examine and describe dynamic patterns of infectious diseases such as influenza and measles (10).

Since the onset of the COVID-19 pandemic, researchers have applied DMD to examine the spatiotemporal characteristics of the spread of COVID-19 (11,12) and found that changes in the mobility of people over geographic space influence its spread (13). However, these studies focused on either a single US state (Florida) or a single nation (South Korea, a country with a land area smaller than Florida). These studies were not designed to show patterns of large-scale migration of COVID-19 between larger geographic regions.

We used DMD to investigate the dynamic pattern of COVID-19 in the US. Specifically, DMD decomposes the spatiotemporal evolution of the number of COVID-19 cases into linear combinations of simple spatial modes that reveal hidden dynamic behaviors. Each mode represents a distinct basis vector, and each element in the vector indicates the contribution of the corresponding state to the number of COVID-19 cases associated with that mode. Multiplying each mode vector by eigenvalues and a time-dependent coefficient vector and then summing them all will produce the number of COVID-19 cases for each state at different times. Our study aimed to use the features of the extracted modes to describe patterns of the number of COVID-19 cases. Knowledge about these early-stage patterns can inform public health officials and policy makers intervening on COVID-19 and future pandemics to help mitigate transmission across populations.

Methods

We first collected data on the number of COVID-19 cases in the US from April 6, 2020, to October 9, 2020 (187 days), from the COVID-19 Tracking Project (14) and normalized them to present a clear view for comparison between different geographic areas by using the following equation:

$$X^* = (X - \min(X))/(\max(X) - \min(X))$$

where X is a matrix of the cumulative number of COVID-19 cases, with rows for states and columns for days, and X^* is the normalized case number. The selection of the cumulative number of COVID-19 cases is to ensure a stable and accurate representation of disease spread by DMD modes (spatial patterns or structures). An alternative would have been to analyze daily incidence data, but these data fluctuate strongly and are difficult to model through DMD. Next, we applied the theory of DMD on infectious diseases (10) to conduct the DMD analysis on COVID-19 data and took the following steps:

Step 1: Create matrices X_1 and X_2 with 1 shifted time step based on the data on number of COVID-19 cases (ie, $X_1 = [x_1, x_2, \ldots, x_{n-1}]$, $X_2 = [x_2, x_3, \ldots, x_n]$) where x_i is a column vector in a time sequence at time step i, with each element representing the count of COVID-19 cases at a specific geographic location.

Step 2: Conduct singular value decomposition, a matrix factorization technique that expresses a matrix as a combination of singular vectors and singular values on the matrix X_1, and use the results to build the approximation A matrix such that $X_2 \approx AX_1$.

Step 3: Decompose the approximation A matrix into eigenvectors and eigenvalues; then obtain DMD modes. Eigenvectors are special vectors that change in magnitude only when multiplied by a matrix, and eigenvalues are the corresponding scaling factors for those eigenvectors.

Step 4: Analyze the properties of the DMD modes to investigate the spatiotemporal dynamics of the cumulative number of COVID-19 cases. Data on the cumulative number of COVID-19 cases can be reconstructed as a linear combination of the product of DMD modes, eigenvalues, and time-dependent–mode amplitudes and coefficients.

The distributions of eigenvalues on the eigenvalue spectrum demonstrate their spatiotemporal behaviors, such as the increase, decrease, and periodic fluctuations or variations in disease incidence or prevalence over time. In each dynamic mode vector, every element has 2 critical components: magnitude and angle. The magnitude of each element in the mode vector associated with each state indicates the degree of contribution of that mode to the total cumulative number of COVID-19 cases in that state. The larger the magnitude for that mode, the more contribution the mode makes to the total number of COVID-19 cases for that state. The phase of the element in the mode vector (ie, the angle between the real and imaginary components of the element) indicates the phase difference between that state relative to other states oscillating at the frequency associated with that mode. The smaller the phase difference between 2 states, the closer they oscillate together (10).

The proper modes were chosen based on the value of $\lambda_k^{\alpha}\|\phi_k\|$ (the modes with the largest $\lambda_k^{\alpha}\|\phi_k\|$) where α is set as 20, representing a scaling factor to avoid those rapid decaying modes on the system. Further details can be seen in previous studies (6,10). The spatial resolution was determined by state, and the temporal resolution was defined by days. The plots of the eigenvalue spectrum were in a complex plane where *x* and *y* coordinates corresponded to the real and imaginary parts of the eigenvalue, respectively.

We used MATLAB version 2020 (MathWorks) codes to plot the total number of COVID-19 cases and daily increments (the daily increase in number of COVID-19 cases) in the 50 US states, the District of Columbia, and 5 US territories (American Samoa, Guam, Northern Mariana Islands, Puerto Rico, US Virgin Islands) from April 6, 2020, to October 9, 2020. For simplicity, this article refers to all 56 jurisdictions as states. We also created separate plots for 6 states: California, Florida, Georgia, North Dakota, South Dakota, and Texas. We selected these 6 states because they demonstrated distinct patterns of spread in COVID-19 cases during the study period, with California, Florida, Georgia, and Texas standing out due to their large populations and unique spikes in cases and North Dakota and South Dakota highlighting late-period surges. We visualized both the raw and normalized data on COVID-19 cases and developed DMD modes. These visualizations allowed us to depict aggregated data on the number of COVID-19 cases and the dynamic patterns of these cases in the US.

We scripted MATLAB codes to process data and execute DMD analysis, and we used the MATLAB mapping toolbox to visualize the results on the maps.

Results

In general, in the 6 states studied, the cumulative number of COVID-19 cases increased slowly in the first 100 days and then increased quickly in the remaining days for nearly all 6 states (Figure 1). California, Florida, Georgia, and Texas showed peaks in daily increments around 100 days, while North Dakota and South Dakota kept increasing during the study period.

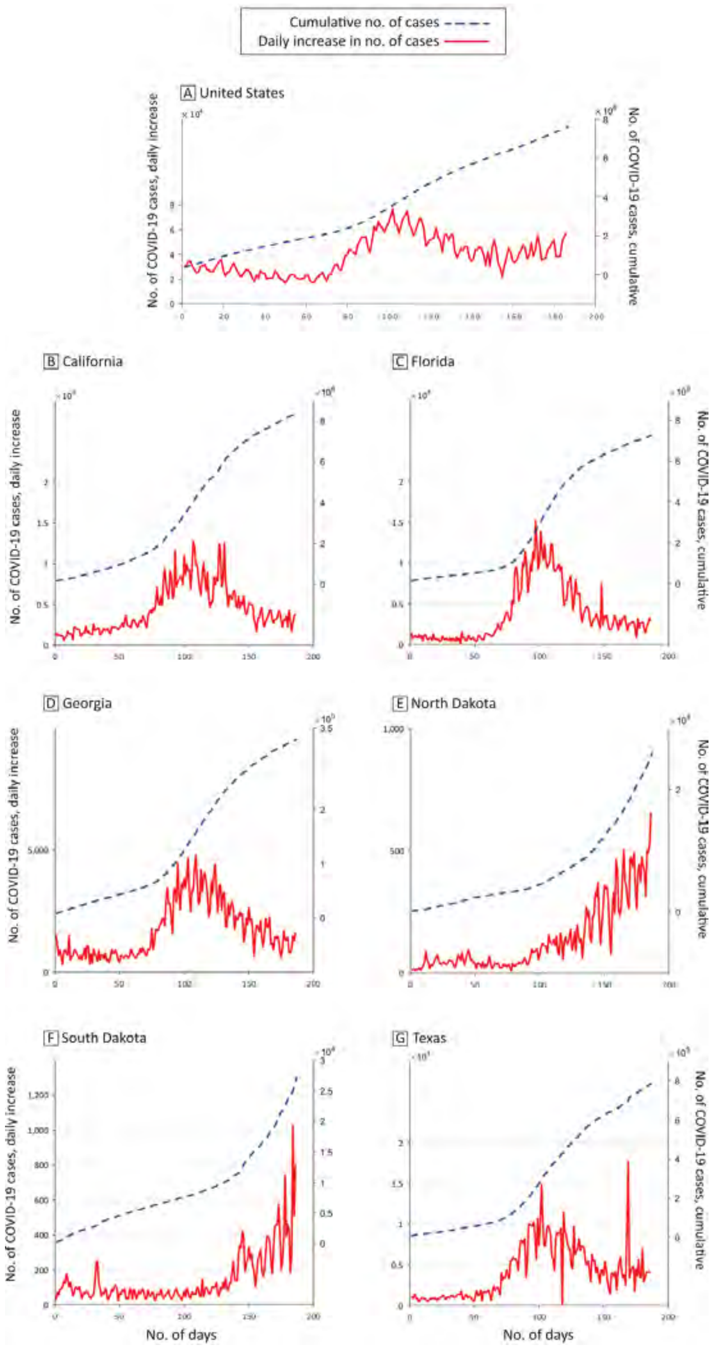

Figure 1. The cumulative number of COVID-19 cases (dashed line) and daily increments (solid line) in the US (A) and in 6 states, April 6, 2020, to October 9, 2020. B, California. C, Florida. D, Georgia. E, North Dakota. F, South Dakota. G, Texas. Data source: COVID-19 Tracking Project (14).

Figure 2 shows the DMD analysis for COVID-19 data in the US. Specifically, Figure 2A presents the aggregated raw data on the number of COVID-19 cases by state. Figure 2B shows the normalized data, with each row representing a state. Rows are ordered from top to bottom alphabetically by the postal state abbreviation for each state: Alaska (AK) is at the top in the first row, and Wyoming (WY) is at the bottom in the last row. California, Florida, and Texas (corresponding to bright yellow rows) clearly show an increase in COVID-19 cases after approximately 100 days in August 2020. New Jersey and New York State had a relatively high number of COVID-19 cases, which did not increase much during the study period. The plot for truncation energy (Figure 2C) indicates that the selected truncation order (reducing the size of the matrix while still conserving sufficient data for accurate and efficient decomposition) was sufficient for our DMD analysis. Truncation energy is defined as the ratio of cumulative sum of the magnitude of the selected eigenvalues over the sum of all the eigenvalue magnitude. The truncation energy value is 99.97% when the truncation order is set at 40. From the implementation of DMD, we conducted mode selection (Figure 2D) according to their frequencies and the spectrum of the eigenvalues (Figure 2E). The spectrum of the eigenvalues shows that many pairs of eigenvalues are inside the unit circle, and thus have decaying characteristics (ie, a temporal reduction in the number of COVID-19 cases). Some pairs of eigenvalues are on the border; these pairs will neither grow nor decay and will provide oscillatory characteristics if the imaginary part of the eigenvalue is not zero. A few eigenvalues reside outside of the unit value, indicating growing characteristics. Figure 2F shows the visualization of the eigen mode matrix for 56 regions (including states and US territories) with the truncation order set at 40.

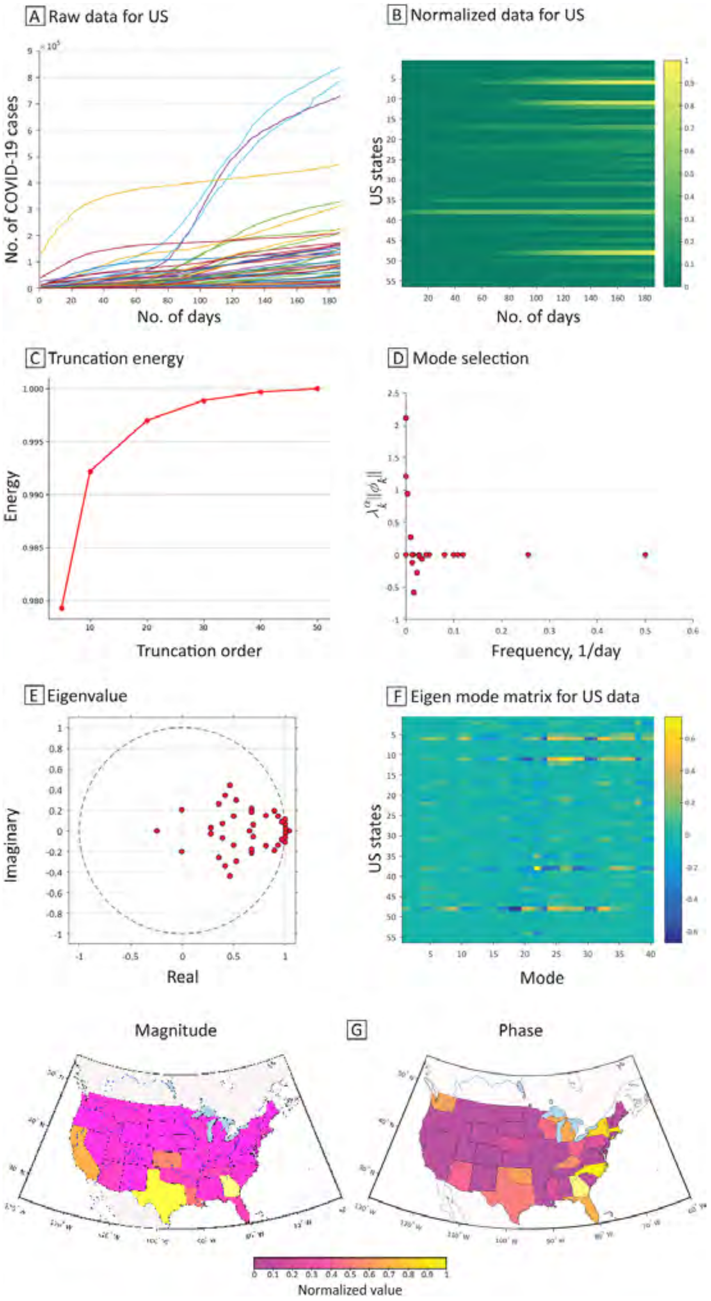

Figure 2. Dynamic mode decomposition analysis of COVID-19 transmission in the US, April 6, 2020, to October 9, 2020. A, The spread of COVID-19 cases in each state, territory, and the District of Columbia. B, The normalized data for each state, territory, and District of Columbia. C, Truncation energy. D, The plot $\lambda_k^\alpha\|\phi_k\|$ versus frequency. E, The eigenvalue spectrum. Dots in the circle indicate decaying of COVID-19 cases, dots on the circle indicate oscillating of COVID-19 cases, and dots outside of the circle indicate spreading of COVID-19 cases. F, The eigen mode matrix for the US data indicates the contribution from each geospatial location. G, The magnitude of the selected mode (the dominant mode with ω = 0, $\lambda_k^\alpha\|\phi_k\|$ = 2.1147) that has the highest $\lambda_k^\alpha\|\phi_k\|$. The magnitude plot shows that California, Louisiana, Kansas, Georgia, and

Texas have more COVID-19 cases than other states. Phase plot indicates that Arizona, Florida, Texas, New York, and Washington State were arriving at the peak of COVID-19 cases close in time. Data source: COVID-19 Tracking Project (14).

Figure 2G shows a dynamic pattern of COVID-19 case numbers from the dominant mode (ie, frequency = 0), as represented by magnitude and phase of the dominant mode, which is scaled by $\lambda_k^{\alpha}\|\phi_k\|$. Magnitude is a measure of a state's contribution to COVID-19 transmission; the map shows a pattern of high magnitude in California, Louisiana, Kansas, Georgia, and Texas. Phase describes the timing and relative position of COVID-19 spread within the region that the mode captures. In the map of phase, regions with similar colors can be viewed as a well-connected group, indicating that these regions simultaneously experienced the spread of COVID-19 (in phase) at the oscillating frequency associated with the mode, even though these regions may not be geographically connected. States that were not neighbors but shared similar phase information, such as Arizona, Florida, Texas, and Washington, or California and Maine, were connected in a way that may have resulted from the transportation of COVID-19 patients or from coincidence.

Discussion

Our study illustrates the application of DMD in analyzing early data on the COVID-19 pandemic. DMD allowed us to examine the underlying patterns of the spread of COVID-19 without requiring assumptions about the transmission mechanism or prior knowledge of the epidemiology of the disease. As a data-driven tool, DMD is versatile and can accommodate various data formats and units of measurement, such as time series, spatial, and multivariate data, and even irregularly sampled data, as long as the data are consistent in the dataset. As such, DMD is suitable for exploring transmission patterns of epidemiologic diseases. Particularly in the early stages, when a pathogen's characteristics are not well-defined and the transport of infected, exposed, or asymptotic patients can spread the disease in nonadjacent geolocations, DMD can identify coherent spatiotemporal patterns and dynamic modes that represent dominant behaviors in disease spread for different geographic areas. DMD can also facilitate short-term forecasting of infectious disease dynamics. Such analyses and their results provide public health professionals and policy makers with knowledge to make better-informed decisions about strategies to mitigate disease transmission.

In this study, we used DMD and COVID-19 data to examine dynamic patterns of the spread of COVID-19. The early pandemic strongly affected California, Louisiana, Kansas, Georgia, and Texas, according to the magnitude analysis. The phase map showed the simultaneous increase of COVID-19 cases in Arizona, Florida, Georgia, Massachusetts, New York, North Carolina, Oklahoma, Texas, and other states. This pattern is consistent with the timeline reported on March 3, 2020, by the Centers for Disease Control and Prevention: 60 cases of COVID-19 across Arizona, California, Florida, Georgia, Illinois, Massachusetts, New Hampshire, New York, Oregon, Rhode Island, Washington, and Wisconsin (15). Our results demonstrated patterns of early COVID-19 transmission that were similar to patterns demonstrated by other studies that used different models. For example, McMahon and colleagues (5) applied a spatial correlation analysis on new active cases and found that from April 2020 to October 2020, the epidemic did not progress uniformly: counties in California and Texas had a greater increase than other states in the number of COVID-19 cases. In another study, which used k-means clustering and principal component analysis (16), California and Texas shared similar transmission patterns from March 1 to May 31, 2020, and were grouped into the same cluster. This finding is notable given the close connections of the 2 states and similar containment and mitigation strategies adopted early in the pandemic (17).

Limitations

Our study has several limitations. One limitation of DMD is its fundamentals of linearity; the data are analyzed on the basis of an approximation of linear relationships, which may only sometimes be the case in real-world applications. For example, the per-capita analysis and the daily incidence analysis did not show accurate reconstructed results by DMD modes. A possible reason for the unreliable results obtained by the per-capita analysis could be population differences. States vary substantially in population size. In addition, populations are not homogeneous in demographic composition; for example, health care needs differ among age groups because of different health concerns. Additionally, the complex spatial structures of COVID-19 transmission patterns, such as the emergence of new variants and the effect of local medical resources and responses, may challenge the ability of DMD to accurately model the spreading of COVID-19 in long-term surveillance of pandemics. Future studies can include various types of data, such as data on use of health care resources, the number of COVID-19 test kits allocated, the number of vaccines administered, and use of personal protective equipment. Such enhanced data could help the DMD model produce more detailed insights into the pandemic's characteristics, all of which could aid decision makers in developing more effective responses.

Conclusion

Our study provides insights into the transmission dynamics of COVID-19 in the US and can inform the development of evidence-based public health policies and interventions for

COVID-19. Our findings can contribute to a better understanding of the characteristics of early COVID-19 transmission and provide decision makers with timely and accurate information to respond to the pandemic and future public health emergencies.

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ORIGINAL RESEARCH

Discrimination and Adverse Perinatal Health Outcomes: A Latent Class Analysis

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PEER REVIEWED

Summary

What is known on this topic?

Discrimination is consistently associated with poor health outcomes and health disparities, including for perinatal health, yet few studies address intersectional discrimination.

What is added by this report?

We evaluated discrimination based on multiple social identities and assessed differential associations with adverse perinatal health outcomes. We found that Black and White participants exposed to general discrimination were more likely to experience symptoms of postpartum depression and that White participants delivered more low birthweight infants relative to those who experienced no discrimination.

What are the implications for public health practice?

Perceived discrimination in pregnancy can be associated with adverse perinatal health outcomes. Addressing intersectional discrimination exposure may promote perinatal health.

Abstract

Introduction

An intersectionality framework recognizes individuals as simultaneously inhabiting multiple intersecting social identities embedded within systems of disadvantage and privilege. Previous research links perceived discrimination with worsened health outcomes yet is limited by a focus on racial discrimination in isolation. We applied an intersectional approach to the study of discrimination to examine the association with adverse perinatal health outcomes.

Methods

We analyzed data from a cohort of 2,286 pregnant participants (Black, n = 933; Hispanic, n = 471; White, n = 853; and Other, n = 29) from the Centering and Racial Disparities trial. Perceived discrimination was assessed via the Everyday Discrimination Scale (EDS) and perinatal health outcomes collected via electronic medical record review. Latent class analysis was used to identify subgroups of discrimination based on EDS item response and the rate of adverse perinatal health outcomes compared between subgroups using a Bolck, Croon and Hagenaars 3-step approach.

Results

Four discrimination subgroups were identified: no discrimination, general discrimination, discrimination attributed to one or several social identities, and discrimination attributed to most or all social identities. Experiencing general discrimination was associated with postpartum depression symptoms when compared with experiencing no discrimination among Black (9% vs 5%, $P = .04$) and White participants (18% vs 9%, $P = .01$). White participants experiencing general discrimination gave birth to low birthweight infants at a higher rate than those experiencing no discrimination (11% vs 6%, $P = .04$). No significant subgroup differences were observed among Hispanic participants.

Conclusion

Perceived discrimination may play an influential role in shaping perinatal health. More research applying an intersectional lens to the study of discrimination and perinatal health outcomes is needed.

Introduction

Racial and ethnic disparities in perinatal health are present across many countries but are particularly pronounced in the US. Infants of Black pregnant people die at more than twice the rate of those of White people, and Black pregnant people themselves are 3 times more likely to die during pregnancy (1,2). Perinatal health disparities are also seen by health insurance status, age, and weight

(2–4). One explanation for the origin of these disparities is the increased burden of stress associated with exposure to persistent discrimination experienced over the life course. Discrimination is thought to affect health through dysregulation of psychological and physiological stress responses systems (eg, altered hypothalamic-pituitary-adrenal axis activation; elevated blood pressure, heart rate, and cortisol production; and inflammation) and accelerated aging, as well as through altered engagement in health behaviors (increased participation in unhealthy behaviors and nonparticipation in healthy behaviors) (5,6). A large and growing body of research demonstrates the negative effect of perceived discrimination on health (7) and suggests that discrimination is a risk factor for adverse perinatal health outcomes (APHOs) including preterm birth (PTB), low birthweight (LBW), small for gestational age, and hypertensive disorders of pregnancy (8).

Existing literature assessing the impact of discrimination on health has been limited by a focus on discrimination based on a single dimension, most commonly race-based discrimination (9). A focus exclusively on racial discrimination may mask complexities in the maternal discrimination experience and potentially underestimates the overall impact of discrimination on perinatal health (10). Adopting an intersectionality framework recognizes that individuals simultaneously occupy multiple interconnected social identities (eg, race, ethnicity, gender, sexual orientation, socioeconomic status) that confer privilege or disadvantage (11,12). Latent class analysis (LCA) offers one method to apply an intersectional approach in quantitative analysis (13). LCA is a data-driven method that probabilistically assigns individuals to latent subgroups based on observed categorical indicator variables (14).

In this study, we aimed to 1) classify mutually exclusive subgroups of pregnant people based on patterns of response to Everyday Discrimination Scale (EDS) items through LCA and 2) examine whether subgroups characterizing different patterns of discrimination were differentially associated with APHOs.

Methods

Participants, design, and setting

We analyzed data from the Centering and Racial Disparities (CRADLE) study (ClinicalTrails.gov identifier no. NCT02640638), a randomized controlled trial of pregnant people (N = 2,348) conducted at a single obstetrics and gynecology practice in Greenville, South Carolina. The primary objective of the CRADLE study was to compare the rate of PTB and LBW of patients who participated in group prenatal care (GPNC, a novel model of prenatal care combining clinical assessment, prenatal education, and peer socialization) with their counterparts in standard individual prenatal care (IPNC), as well as racial disparities in these outcomes. The CRADLE study was approved by the Prisma Health institutional review board (no. Pro00043994). The full study protocol and primary findings have been published previously (15,16).

The study population was medically low-risk pregnant people of diverse races and ethnicities. Eligible patients were aged between 14 and 45 years, were less than 24 weeks gestational age at enrollment, and were proficient in English or Spanish. Exclusion criteria were medical or pregnancy complications that would preclude prenatal care and delivery by a nurse practitioner or nurse midwife (ie, pregestational diabetes, chronic hypertension requiring medication, any disease requiring immunosuppression, a body mass index of more than 50 kg/m^2, multiple gestation, patients anticipating a planned preterm delivery or planned cerclage, or lethal fetal anomalies) or patients with medical, social, or behavioral conditions that would preclude participation in group care (ie, active pulmonary tuberculosis, current incarceration, or severe uncontrolled psychiatric illness). In the CRADLE study, participants were randomly allocated 1:1 stratified by race and ethnicity to attend GPNC or IPNC. Trial intervention and control groups were combined and included in our analysis.

Data collection

Study recruitment took place between February 2016 and March 2020. Participants were followed from enrollment through delivery and 12 weeks postpartum. Data were collected at 3 points: 1) an initial survey at the baseline visit between 8 and 23 weeks gestational age, 2) a second survey between 30 and 40 weeks gestational age, and 3) a medical chart abstraction 12 weeks postpartum. Surveys included demographic questions and various psychosocial and behavioral measures. Medical and delivery information were collected through manual chart abstraction as well as automated query of the electronic medical record (EPIC Systems Inc).

Measures

Indicator variables used to define unobserved latent class membership comprised patient response to the adapted 11-item Everyday Discrimination Scale (EDS) administered at baseline (17). The EDS is among the most commonly used measures of discrimination and has high reliability and construct validity (8). The EDS attempts to measure chronic but minor instances of discrimination. It first asks respondents about their day-to-day experience of 10 forms of unfair treatment. Response values are on a 4-point Likert scale ranging from “never” to “often.” Respondents who indicate any discrimination are then asked to identify the reasons for their mistreatment and can select multiple reasons including those related to gender, race and ethnicity, insurance and Medicaid status, ancestry and national origin, age, religion, weight or some other aspect of physical appearance, sexual orientation, and education or income level. We formed a binary variable of discrimination frequency consisting of "never" versus "rarely, sometimes, or often." Each attribution for discrimination was coded as a binary variable with possible responses of either yes or no; attributions with low prevalence were combined to form an "other" discrimination variable.

The primary outcome was a composite measure of APHOs. A binary variable was created representing indication of none versus 1 or more of the following 7 outcomes: PTB (delivery at <37 weeks gestation); LBW (infant birthweight <2,500 g); small for gestational age (SGA, birthweight below the 10th percentile for gestational age); infant admission to the neonatal intensive care unit (NICU); 5-minute Apgar score <7; pre-eclampsia; and patient admission to the intensive care unit (ICU). Individual APHO's composite components, as well as postpartum depression symptoms (PPDS), were considered as secondary outcomes. PPDS was identified based on Edinburgh Postnatal Depression Scale (EPDS) response (18). The EPDS is a widely used 10-item screening instrument for depression risk, which has high sensitivity and specificity in detecting depressive disorders with a cutoff of 13 (19). The EPDS was routinely administered at the postpartum outpatient visit as part of routine clinical care and the results abstracted from the medical record at 12 weeks postpartum; we used a binary PPDS variable (scores <13 vs ≥13).

Self-reported sociodemographic characteristics were collected through the baseline survey and included race and ethnicity (Black, Hispanic, White, or other); age (14–24 y, 25–34 y, and 35–45 y); Medicaid eligible (yes or no); educational attainment (less than high school, high school degree, more than high school degree); current relationship with baby's father (categorized as married, engaged, or in a committed dating relationship, or single or other relationship); nativity (born in the US vs born outside the US); parity (nulliparous vs primiparous or multiparous); and body mass index (BMI) at initial prenatal care visit (underweight, <18.5 kg/m^2; healthy weight 18.5 kg/m^2 to <25.0 kg/m^2; overweight 25.0 kg/m^2 to <30.0 kg/m^2; or obese, ≥30.0 kg/m^2). Participants identified their race and ethnicity through questions used by the US Census Bureau, which allowed participants to select multiple categories, as well as providing a space for open-ended description of race and ethnicity (20).

Statistical analyses

All statistical analyses were performed by using SAS version 9.4 (SAS Institute, Inc). First, sample characteristics were described and differences by race and ethnicity were examined by using χ^2 tests. LCA models were then estimated by using SAS PROC LCA and the LCA Bootstrap Macro (21,22). To identify an optimal LCA model, models with between 1 and 6 latent classes were tested. Optimal models were indicated by minimum Akaike information criterion (AIC) and Bayesian information criterion (BIC) values in addition to the Bootstrap Likelihood Ratio Test (BLRT) that compares model fit for k classes relative to k+1 classes. Two primary sets of parameters were estimated: class membership probabilities (the size of the latent class identified) and item response probabilities (the conditional probability of a response given class membership). Item response probabilities were used to label latent classes. A likelihood ratio difference test was used to test equality across race and ethnicity following a 3-step approach, and race and ethnicity groups were modeled separately (14).

The Bolck, Croon and Hagenaars (BCH) 3-step approach was used to assess whether latent classes were associated with APHOs, applied separately for each outcome (23). Parameters of the LCA model were first estimated without distal outcomes, posterior probabilities of latent class membership were then used to compute a weighting variable, and the association between the weighted variable and the distal outcome were investigated using logistic regression. The %LCA_Distal_BCH macro provides an overall test of association between class membership and outcomes of interest, as well as pairwise comparisons of the expected values between classes using Wald tests (23). A *P* value of <.05 was considered significant.

A sensitivity analysis using maximum-probability assignment was performed. Multiple logistic regressions were conducted to test whether prenatal care assignment in the CRADLE study modifies the link between latent classes and APHOs.

Results

Descriptive statistics

Of the 2,348 CRADLE study participants, 2.6% (n = 62) participants were excluded due to missing values on all indicator variables, resulting in a final analytic sample of 2,286. More than 40% of the sample identified as Black, 20.6% as Hispanic, 37.3% as White, and 1.3% as other race and ethnicity (Table 1). Most participants were aged 25 to 34 years (76.8%), Medicaid eligible (96.4%), had a high school education (53.6%), were engaged or in a committed relationship with the baby's father (39.9%), had previously given birth (55.5%), were born in the US (83.9%), and were overweight or obese (64.3%). The frequency of these sociodemographic characteristics significantly differed across racial and ethnic groups (*P* < .001).

Measures of discrimination

Half of participants (51.1%) reported experiencing discrimination rarely, sometimes, or often (Table 1). Many participants attributed discrimination to age (15.1%), followed by race and ethnicity (14.2%), weight or some aspect of physical appearance (11.6%), gender (11.3%), education or income (9.9%), and other characteristics (6.5%). Apart from attribution to the combined "other" characteristic variable, participant reports of discrimination significantly differed by race and ethnicity ($P < .001$). Fewer Hispanic participants (42.7%) reported experience of discrimination relative to Black (51.6%) and White (54.9%) participants. White participants were least likely to attribute discrimination to race or ethnicity (4.3%) and to any "other" characteristic (5.5%), while Hispanic participants were least likely to attribute discrimination to all other factors (5.5%–5.9%).

Overall, 31.9% of the sample had an APHO (Table 1). Black participants had a higher rate of APHOs (38.3%, n = 357) relative to Hispanic (24.8%, n = 117) and White (29.5%, n = 252) participants. Prevalence of individual outcomes ranged from less than 1% for ICU admission to 17.5% for small for gestational age. White participants (14.4%) had higher rates of PPDS than Black (7.7%) and Hispanic (5.8%) participants. Due to collection at the postpartum visit, missingness on the PPDS variable was considerably higher than for other outcome variables (719 [31.5%] participants).

Latent class models

Fit indices for models ranging from 1 to 6 classes are presented in Table 2. Classes 1–4 were well identified (higher % of seeds associated). Entropy for models ranged between 1.00 and 0.80, suggesting low classification uncertainty. The BIC suggests a 3-class model, while the AIC suggests that a 4-class model offers the best fit. The 4-class model was supported by the BLRT and yielded interpretable and meaningful classes; it was therefore selected to offer the best fit. Table 3 displays the latent class profiles and labels for the 4-class model.

The likelihood-ratio difference test indicated that underlying LCA measurements differed significantly across racial and ethnic groups ($\Delta G^2 = 100.7$, $df = 56$, $P < .001$). Thus, race/ethnicity–specific latent class models were estimated. Participants reporting other race and ethnicity were excluded from stratified LCA because of the small sample size. Fit indices and interpretability indicated a 4-class model as the best fit for each racial and ethnic group (Table 2).

Race and ethnicity stratified models

Similar and different latent classes emerged in race and ethnicity stratified models (Table 3). Among all racial and ethnic groups, the "no discrimination" class was the largest (range, 45.6%–59.2%). The second largest class for each race and ethnicity (range, 31.0%–41.5%) was the "general discrimination" class, which experienced discrimination, although participants had a low probability of attributing discrimination to any particular characteristic. Only Hispanic participants in the general discrimination class had a moderate probability of attributing discrimination to race and ethnicity.

The 2 smaller classes of maternal discrimination in each race and ethnicity varied. Among Black participants, the third largest class (12.5%), "gender, race and ethnicity, and age discrimination," experienced discrimination and had a high probability of attributing discrimination to gender, race and ethnicity, and age but a low probability of attributing discrimination to other characteristics. Participants in the fourth and smallest class (5.6%), "compound discrimination," experienced discrimination and had a high probability of attributing discrimination to all characteristics.

Among Hispanic participants, the third largest class (6.1%), "other discrimination," experienced discrimination and had a high probability of attributing discrimination to characteristics in the other discrimination category. The fourth and smallest class (3.6%), "compound discrimination," experienced discrimination and had a high probability of attributing discrimination to all characteristics except age and weight and appearance, for which they had a moderate probability.

Among White participants, the third largest class (7.0%), "education, income, weight and appearance, and age discrimination," experienced discrimination and had a high probability of attributing discrimination to education, income, weight and appearance, and age but a low probability of attributing discrimination to other characteristics. White participants in the fourth and smallest class (5.8%), "compound discrimination," experienced discrimination and had a high probability of attributing discrimination to gender, age, and weight and appearance, as well as a moderate probability of attributing discrimination to other characteristics.

Association with adverse perinatal health outcomes

Estimated outcome probability for each latent class and pairwise comparisons between each latent class are displayed in Table 4 and Table 5, respectively. Our focus is on results of the race and ethnicity–stratified models, as they were determined to best fit the data.

Among Black participants, pairwise comparisons indicated that the expected probability of severe or moderate PPDS were significantly higher for the general discrimination class relative to the no discrimination class (9% vs 5%, $P = .04$). No other significant latent class differences were identified in the Black sample. Among Hispanic participants, pairwise comparisons did not show any significant between-class differences in outcomes that could be compared. Among White participants, pairwise comparisons indicated that the expected probability of severe or moderate PPDS for the general discrimination class was significantly higher than for the no discrimination class (18% vs 9%, $P = .01$). Additionality, the probability of LBW for the general discrimination class was significantly higher than for the no discrimination class (11% vs 6%, $P = .04$). Finally, among White participants, expected probability of composite APHO was significantly lower for the compound discrimination class than the general discrimination class (12% vs 35%, $P = .02$). No further significant differences in outcomes by class were observed in the White sample.

Prenatal care assignment as an effect modifier

In analysis using maximum-probability assignment, prenatal care assignment was not found to significantly modify the relationship between discrimination subgroups and APHOs. However, among Black pregnant participants, prenatal care assignment significantly modified the relationship between discrimination subgroups and PPDS ($\beta = 2.04$, $P < .05$), such that individuals in the "gender, race and ethnicity, and age discrimination" class assigned to GPNC had 5.17 (95% CI, 1.56–17.11) times the odds of PPDS than those in the "No Discrimination" class, while individuals in the "gender, race and ethnicity, and age discrimination" class assigned to IPNC had 0.67 times the odds of PPDS relative to those in the no discrimination class.

Discussion

We used an intersectionality framework to explore pregnant people's varied and intersecting exposure to discrimination and its effect on birth outcomes. Discrimination varied significantly across race and ethnicity; therefore, models were estimated separately for each race and ethnicity. We identified 4 unique classes of self-reported discrimination. The largest 2 subgroups of discrimination in each race and ethnicity included participants who reported never experiencing discrimination (no discrimination) and participants who experienced discrimination but did not strongly attribute discrimination to any one characteristic (general discrimination). The smaller 2 subgroups were more varied, including one class with a high probability of attributing discrimination to a single or multiple characteristic and one class with a high or moderate probability of attributing discrimination to most or all characteristics. Discrimination subgroups identified are consistent with previous studies of intersectional discrimination, which have largely taken place among older adults (24–26) and in which similar classes of no/minimal discrimination, single/general attribution, several/multiple attributions, and high/all attributions were identified.

Further, we found pregnant people's risk of developing some APHOs significantly differed by discrimination subgroup. Black and White participants experiencing general discrimination were found to be at an increased risk of PPDS relative to participants who did not experience discrimination. This finding is congruent with existing literature that demonstrates an association between discrimination and PPDS. Analysis of the Pregnancy Risk Assessment Monitoring System (PRAMS) postnatal survey suggests that respondents who report being upset by race-based discrimination in the prior year are more likely to identify as experiencing PPDS, with the strongest relationship seen for Black participants (27–29).

Contrary to previous studies, our analysis did not show a significant association between maternal discrimination and PPDS among Hispanic participants. This finding may reflect protective factors against the effect of discrimination in this community. Relative to other racial and ethnic groups, Hispanic participants had lower rates on all APHOs measured. A robust literature suggests that despite lower socioeconomic status, Hispanic people defy the socioeconomic gradient of health in demonstrating good health outcomes, a phenomenon known as the Hispanic Paradox (30). It is hypothesized that sociocultural norms and values such as social support and religiosity may buffer Hispanic people against health disparities (31). Studies find that the Hispanic Paradox deteriorates with increased time in the United States and among subsequent generations (32). Most Hispanic participants in our sample (65.6%) were born outside the US and may therefore have had less exposure to the social context inside the US.

Among White participants, those who experienced general discrimination also had a higher risk of delivering an LBW infant relative to participants who did not experience discrimination. Although this finding is consistent with extant literature supporting the association between self-reported discrimination and risk of APHOs, it being observed only among White participants was unanticipated, as the relationship has previously been seen to be most robust among Black pregnant people (8). White participants reported the highest rate of discrimination in our sample. We incorporated assessment of self-reported day-to-day discrimination based on multiple social identities; therefore, findings may be due to the high prevalence of discrimination based on social identities other than race and ethnicity among White participants. Relative to other racial and ethnic groups, White participants were most likely to be younger and to attribute their discrimination to age. Findings might also reflect differential measure interpretation across racial and ethnic groups. While many studies attest to the EDS's strong psychometric properties, recent findings raise concerns about the instrument's equivalence across diverse social groups (33). Interpretation of EDS questions may differ across racial and ethnic groups; White participants may be more likely to interpret the scale as asking about unfair treatment generally rather than specifically about social injustice (34).

An additional unexpected finding of our analysis was that White participants who experienced compound discrimination were less likely to experience an APHO relative to those who experienced general discrimination. This finding is the opposite relationship than would be predicted by an intersectionality framework and paired with other findings could suggest unique risks among the general discrimination subgroup. Alternatively, this finding may be an artifact of the compound discrimination subgroup's small class size.

Although previous studies suggest that GPNC may reduce racial disparities in birth outcomes (35), GPNC was not found to buffer against the effects of discrimination class on APHOs in our study.

Limitations

Our study has limitations. First, although our sample is relatively large, subanalyses by race and ethnicity further subdivide the sample, limiting power to detect differences in low prevalence outcomes. For this reason, discrimination subgroups representing discrimination attributed to one, many, or all characteristics may not have been significantly associated with greater risk of APHOs in our sample. Second, because the sample included largely Medicaid-eligible pregnant people with low medical risk from a single practice, findings may therefore not be generalizable to other populations. Moreover, our focus on medically low-risk pregnancies may have resulted in attenuated associations, particularly among Black people who might be expected to have worsened health at entry to prenatal care due to disadvantages across the life course. Finally, at this time the BCH distal outcome procedure in SAS is not equipped to accommodate covariates; therefore, our findings do not control for other potentially confounding factors. Although strategies exist that can accommodate covariates, the BCH approach has been found to be more accurate than these alternatives, considering uncertainty in class assignment (36,37). Analyses conducted using maximum-probability assignment should be interpreted with caution.

Strengths

Our study also has several strengths. First, we applied a novel statistical approach, LCA, to explore experiences of discrimination during pregnancy. LCA moves beyond a single status analysis, providing a more comprehensive assessment of discrimination during pregnancy and its association with APHOs. The person-centered nature of LCA supports the application of an intersectional approach in which multiple social identities are jointly considered. Second, our study population was racially and ethnically diverse and was composed primarily of low-income participants. Finally, we had rigorous data collection, including variables from patient self-reported validated measures and through medical chart abstraction.

Conclusion

This study enhances our understanding of discrimination in pregnancy and associated perinatal health outcomes which may inform strategies for perinatal health promotion. Findings highlight the importance of assessing and addressing discrimination as intersectional rather than unidimensional domains. Interventions adopting an intersectionality framework may be best suited to respond to the complex discrimination experiences that impact pregnant people and promote perinatal health. Screening for discrimination exposure as a significant risk factor for adverse perinatal health could be incorporated in prenatal care settings and a systematic surveillance system for discrimination exposure and perinatal outcomes implemented.

Our results align with existing evidence on perceived discrimination as a risk factor for APHOs. By incorporating an intersectionality framework, this study extends understanding of the variety and intersections of discrimination experienced by pregnant people, as well as the association with APHOs, particularly PPDS. Future research that uses a large and representative population-based data set is needed to further clarify subgroups most at risk, as well as factors that may moderate or mediate the deleterious effects of discrimination on perinatal health. Broader research suggests that these factors may include group identification, social support, resilience, and coping strategies (5). This work will be facilitated by the modification and validation of instruments to assess perceived discrimination for use across diverse social groups.

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Tables

Table 1. Sociodemographic Characteristics, Everyday Discrimination, and Adverse Perinatal Health Outcomes of Participants of the Centering and Racial Disparities Study (N = 2,286)

Characteristic/variable	Overall	Black	Hispanic	White	*P* value[a]
	Frequency (%)				
Sociodemographic characteristics					
Race and ethnicity					
Black	933 (40.8)	—	—	—	NA
Hispanic	471 (20.6)	—	—	—	
White	853 (37.3)	—	—	—	
Other	29 (1.3)	—	—	—	
Age, y					
14–24	401 (17.5)	155 (16.6)	74 (15.7)	170 (19.9)	<.001
25–34	1,755 (76.8)	740 (79.3)	343 (72.8)	649 (76.1)	
35–45	130 (5.7)	38 (4.1)	54 (11.5)	34 (3.9)	
Medicaid eligibility					
Eligible	1,970 (96.4)	795 (96.9)	417 (96.1)	734 (96.2)	.63
Ineligible	73 (3.6)	25 (3.1)	17 (3.9)	29 (3.8)	
Educational attainment					
Less than high school	556 (24.3)	150 (16.1)	169 (35.9)	232 (27.2)	<.001
High school degree	1,226 (53.6)	562 (60.2)	202 (42.9)	446 (52.3)	
More than high school degree	460 (20.1)	203 (21.8)	87 (18.5)	162 (18.9)	
Missing	44 (1.9)	18 (1.9)	13 (2.8)	13 (1.5)	
Relationship status					
Married	422 (18.5)	261 (27.9)	52 (11.0)	137 (16.1)	<.001
Engaged or committed dating relationship with the baby's father	913 (39.9)	59 (6.3)	171 (36.3)	180 (21.1)	
Single or other	451 (19.7)	374 (40.1)	176 (37.4)	352 (41.3)	
Missing	500 (21.9)	239 (25.6)	72 (15.3)	184 (21.6)	
Nativity					
Born outside the US	358 (15.7)	23 (2.5)	309 (65.6)	13 (1.5)	<.001
Born in the US	1,917 (83.9)	910 (97.5)	154 (32.7)	838 (98.2)	
Missing	11 (0.5)	0 (0)	8 (1.7)	2 (0.2)	
Initial body mass index, kg/m^2					
Underweight (<18.5)	72 (3.1)	36 (3.9)	8 (1.7)	28 (3.3)	<.001
Healthy weight (18.5 to <25.0)	744 (32.6)	300 (32.2)	136 (28.9)	301 (35.3)	
Overweight (25.0 to <30.0)	577 (25.2)	206 (22.1)	155 (32.9)	207 (24.3)	
Obese (≥30.0)	893 (39.1)	391 (41.9)	172 (36.5)	317 (37.2)	
Parity					

Abbreviation: NA, not applicable.
[a] *P* values determined by using χ^2 test.
[b] Other discrimination includes discrimination attributed to insurance or Medicaid status, ancestry or national origin, sexual orientation, or religion.

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Table 1. Sociodemographic Characteristics, Everyday Discrimination, and Adverse Perinatal Health Outcomes of Participants of the Centering and Racial Disparities Study (N = 2,286)

Characteristic/variable	Overall	Black	Hispanic	White	*P* value[a]
	Frequency (%)				
Nulliparous	1,018 (44.5)	445 (47.7)	170 (36.1)	391 (45.8)	<.001
Primiparous or multiparous	1,268 (55.5)	488 (52.3)	301 (63.9)	462 (54.2)	
Indicator variables					
Frequency of discrimination					
Never	1,117 (48.9)	452 (48.5)	270 (57.3)	384 (45.0)	<.001
Rarely, sometimes, or often	1,169 (51.1)	481 (51.6)	201 (42.7)	469 (54.9)	
Discrimination attribution					
Age	344 (15.1)	156 (16.7)	27 (5.7)	157 (18.4)	<.001
Race and ethnicity	325 (14.2)	189 (20.3)	89 (18.9)	37 (4.3)	<.001
Weight or some other aspect of physical appearance	266 (11.6)	113 (12.1)	27 (5.7)	120 (14.1)	<.001
Gender	259 (11.3)	146 (15.7)	28 (5.9)	80 (9.4)	<.001
Education or income level	228 (9.9)	98 (10.5)	26 (5.5)	102 (11.9)	<.001
Other[b]	148 (6.5)	65 (6.9)	31 (6.6)	47 (5.5)	.44
Outcome variables					
Composite adverse perinatal health outcomes					
None	1,555 (68.0)	576 (61.7)	354 (75.2)	601 (70.5)	<.001
Any	731 (31.9)	357 (38.3)	117 (24.8)	252 (29.5)	
Preterm birth (delivery at <37 weeks gestation)					
No	1,954 (90.5)	784 (89.2)	412 (92.2)	732 (90.7)	.20
Yes	205 (9.5)	95 (10.8)	35 (7.8)	75 (9.3)	
Missing	127	54	24	46	
Low birthweight (infant birthweight <2,500 g)					
No	1,828 (90.8)	702 (87.6)	410 (93.6)	691 (92.3)	<.001
Yes	186 (9.2)	99 (12.4)	28 (6.4)	58 (7.7)	
Missing	272	132	33	104	
Small for gestational age (birthweight below the 10th percentile for gestational age)					
No	1,660 (82.5)	602 (75.3)	394 (89.5)	644 (85.9)	<.001
Yes	353 (17.5)	198 (24.8)	46 (10.5)	105 (14.0)	
Missing	273	133	33	104	
Neonatal intensive care unit admission					
No	1,848 (97.9)	738 (97.9)	402 (99.3)	683 (97.3)	.08
Yes	38 (2.0)	16 (2.1)	3 (0.7)	19 (2.7)	
Missing	400	179	66	151	
Apgar score <7					

Abbreviation: NA, not applicable.

[a] *P* values determined by using χ^2 test.

[b] Other discrimination includes discrimination attributed to insurance or Medicaid status, ancestry or national origin, sexual orientation, or religion.

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Table 1. Sociodemographic Characteristics, Everyday Discrimination, and Adverse Perinatal Health Outcomes of Participants of the Centering and Racial Disparities Study (N = 2,286)

Characteristic/variable	Overall	Black	Hispanic	White	*P* value[a]
	Frequency (%)				
No	2,051 (93.3)	818 (91.6)	436 (95.2)	772 (93.9)	.03
Yes	148 (6.7)	75 (8.4)	22 (4.8)	50 (6.1)	
Missing	87	40	13	31	
Preeclampsia					
No	2,117 (92.6)	856 (91.8)	442 (93.8)	791 (92.7)	.36
Yes	169 (7.4)	77 (8.3)	29 (6.2)	62 (7.3)	
Intensive care unit					
No	2,280 (99.7)	931 (99.8)	470 (99.8)	850 (99.7)	.83
Yes	6 (0.3)	2 (0.2)	1 (0.2)	3 (0.4)	
Postpartum depression					
Score <13	1,413 (90.2)	586 (92.3)	324 (94.2)	486 (85.6)	<.001
Score ≥13	154 (9.8)	49 (7.7)	20 (5.8)	82 (14.4)	
Missing	719	298	127	285	

Abbreviation: NA, not applicable.

[a] *P* values determined by using χ^2 test.

[b] Other discrimination includes discrimination attributed to insurance or Medicaid status, ancestry or national origin, sexual orientation, or religion.

Table 2. Fit Indices for Latent Classes of Maternal Discrimination in the Overall Sample and Among Black, Hispanic, and White Participants, Centering and Racial Disparities Study[a]

	Model	G^2	*df*	AIC	BIC	CAIC	SABIC	BLRT	Entropy	% of Seeds associated
Overall	1-class	2,724.45	120	2,738.45	2,778.60	2,785.60	2,756.36	NA	1.00	100
	2-class	308.26	112	338.26	424.28	439.28	376.62	0.01	0.85	100
	3-class	131.43	104	177.43	309.33	332.33	263.25	0.01	0.88	99.0
	4-class	**84.55**	**96**	**146.55**	**324.32**	**355.32**	**225.82**	**0.01**	**0.85**	**34.0**
	5-class	60.81	88	138.81	362.46	401.46	238.55	0.02	0.88	3.7
	6-class	45.02	80	139.02	408.55	455.55	259.22	0.10	0.80	5.4
Black	1-class	1,407.69	120	1,407.69	1,421.69	1,462.56	1,433.33	NA	1.00	100
	2-class	201.49	112	231.49	231.49	304.06	319.06	0.01	0.89	100
	3-class	89.58	104	135.58	269.86	269.86	173.81	0.01	0.87	100
	4-class	**60.57**	**96**	**122.57**	**272.56**	**303.56**	**174.11**	**0.01**	**0.90**	**34.7**
	5-class	45.42	88	123.42	312.12	351.12	188.25	0.12	0.92	46.7
	6-class	38.08	80	132.08	359.49	406.49	210.22	0.79	0.89	3.5
Hispanic	1-class	514.03	120	514.03	528.03	557.11	564.11	NA	1.00	100
	2-class	78.89	112	108.89	171.21	186.21	123.61	0.01	0.86	100
	3-class	50.70	104	96.70	192.26	215.26	119.26	0.01	0.93	96.6
	4-class	**33.51**	**96**	**95.51**	**224.31**	**255.31**	**125.92**	**0.04**	**0.89**	**50.4**
	5-class	22.39	88	100.39	262.43	301.43	138.65	0.19	0.91	11.3
	6-class	16.17	80	110.17	305.45	352.45	156.28	0.62	0.86	13.7
White	1-class	881.57	120	895.57	928.81	935.81	906.58	NA	1.00	100
	2-class	123.48	112	153.48	224.71	239.71	177.07	0.01	0.81	100
	3-class	69.32	104	115.32	224.54	247.54	151.50	0.01	0.83	100
	4-class	**50.73**	**96**	**112.73**	**259.94**	**290.94**	**161.49**	**0.06**	**0.86**	**44.9**
	5-class	39.63	88	117.63	302.83	341.83	178.98	0.33	0.84	61.5
	6-class	34.56	80	128.56	351.75	398.75	202.49	0.98	0.87	0.3

Abbreviations: AIC, Akaike information criterion; BIC, Bayesian information criterion; BLRT, bootstrap likelihood ratio test; CAIC, consistent AIC; G^2, goodness of fit test; NA, not applicable; SABIC, sample size–adjusted BIC.

[a] Bolded numbers indicate the best-fitting models. A likelihood-ratio difference test (free: $G^2 = 145.96$, *df* = 290; constrained: $G^2 = 246.66$, *df* = 346; $\Delta G^2 = 100.7$, *df* = 56, $P < .00$) indicated that measurement invariance should be rejected.

Table 3. Item-Response Probabilities for 4-Class Models of Maternal Discrimination, Centering and Racial Disparities Study

Indicator items	Item response probabilities			
Overall	**Class 1: no discrimination (49.1%)**	**Class 2: general discrimination (32.3%)**	**Class 3: education and income discrimination (8.8%)**	**Class 4: gender, race and ethnicity, and age discrimination (9.8%)**
Discrimination frequency	0.00	0.99	0.99	0.99
Gender	0.00	0.09	0.00	0.83
Race and ethnicity	0.00	0.21	0.11	0.64
Age	0.00	0.17	0.31	0.67
Education and income	0.00	0.02	0.66	0.34
Weight and appearance	0.00	0.16	0.33	0.37
Other discrimination[a]	0.00	0.05	0.19	0.31
Black	**Class 1: no discrimination (48.9%)**	**Class 2: general discrimination (32.9%)**	**Class 3: gender, race and ethnicity, and age discrimination (12.5%)**	**Class 4: compound discrimination (5.6%)**
Discrimination frequency	0.01	0.99	0.99	0.99
Gender	0.00	0.00	0.91	0.71
Race and ethnicity	0.00	0.24	0.61	0.82
Age	0.00	0.17	0.54	0.79
Education and income	0.00	0.17	0.07	0.69
Weight and appearance	0.00	0.20	0.21	0.50
Other discrimination[a]	0.00	0.08	0.12	0.49
Hispanic	**Class 1: no discrimination (59.2%)**	**Class 2: general discrimination (31.0%)**	**Class 3: other discrimination (6.1%)**	**Class 4: compound discrimination (3.6%)**
Discrimination frequency	0.03	0.99	0.99	0.99
Gender	0.00	0.09	0.00	0.78
Race and ethnicity	0.00	0.45	0.22	0.91
Age	0.00	0.11	0.09	0.41
Education and income	0.00	0.06	0.26	0.54
Weight and appearance	0.00	0.14	0.00	0.34
Other discrimination[a]	0.00	0.00	0.76	0.55
White	**Class 1: no discrimination (45.6%)**	**Class 2: general discrimination (41.5%)**	**Class 3: education, income, weight, appearance and age discrimination (7.0%)**	**Class 4: compound discrimination (5.8%)**
Discrimination frequency	0.01	0.99	0.99	0.99
Gender	0.00	0.09	0.00	0.90
Race and ethnicity	0.00	0.04	0.05	0.34
Age	0.00	0.24	0.49	0.82
Education and income	0.00	0.12	0.67	0.38
Weight and appearance	0.00	0.16	0.62	0.49
Other discrimination[a]	0.00	0.04	0.24	0.39

[a] Other discrimination includes attributions to insurance/Medicaid status, ancestry/national origin, sexual orientation, and religion.

Table 4. Estimated Proportions of Adverse Perinatal Health Outcomes, by Latent Class, Centering and Racial Disparities Study

Item	No. (%)	BCH-estimated probabilities (95% CI)			
Overall (N = 2,286)		**Class 1: no discrimination**	**Class 2: general discrimination**	**Class 3: education and income discrimination**	**Class 4: gender, race and ethnicity, and age discrimination**
APHOs	731 (31.9)	0.32 (0.29–0.35)	0.33 (0.29–0.37)	0.31 (0.22–0.39)	0.31 (0.24–0.39)
PTB	205 (9.5)	0.09 (0.08–0.11)	0.12 (0.09–0.15)	0.04 (0.02–0.12)	0.09 (0.05–0.15)
LBW	186 (9.2)	0.08 (0.07–0.10)	0.09 (0.07–0.12)	0.10 (0.04–0.16)	0.11 (0.06–0.16)
SGA	353 (17.5)	0.17 (0.15–0.19)	0.17 (0.13–0.20)	0.21 (0.13–0.29)	0.18 (0.12–0.25)
NICU	38 (2.0)	0.02 (0.01–0.03)	0.02 (0.01–0.04)	0.01 (0.00–0.08)	0.02 (0.01–0.07)
Apgar <7	148 (6.7)	0.06 (0.05–0.08)	0.07 (0.05–0.09)	0.09 (0.04–0.14)	0.07 (0.03–0.12)
Preeclampsia	169 (7.4)	0.07 (0.06–0.09)	0.08 (0.06–0.10)	0.04 (0.01–0.10)	0.09 (0.06–0.15)
PPDS	154 (9.8)	0.21 (0.12–0.29)	0.06 (0.05–0.08)	0.12 (0.09–0.15)	0.10 (0.05–0.16)
Black (n = 933)		**Class 1: no discrimination**	**Class 2: general discrimination**	**Class 3: gender, race and ethnicity, and age discrimination**	**Class 4: compound discrimination**
APHOs	357 (38.3)	0.38 (0.33–0.42)	0.37 (0.31–0.43)	0.41 (0.30–0.51)	0.43 (0.25–0.62)
PTB	95 (10.8)	0.10 (0.07–0.13)	0.11 (0.07–0.15)	0.09 (0.02–0.15)	0.17 (0.03–0.31)
LBW	99 (12.4)	0.11 (0.08–0.14)	0.13 (0.09–0.18)	0.12 (0.06–0.22)	0.22 (0.09–0.42)
SGA	198 (24.8)	0.23 (0.19–0.28)	0.26 (0.20–0.31)	0.25 (0.17–0.37)	0.34 (0.18–0.55)
NICU	16 (2.1)	0.02 (0.01–0.04)	0.02 (0.01–0.05)	0.03 (0.01–0.11)	0.06 (0.01–0.26)
Apgar <7	75 (8.4)	0.08 (0.05–0.11)	0.09 (0.06–0.13)	0.11 (0.06–0.19)	0.06 (0.01–0.29)
Preeclampsia	77 (8.3)	0.08 (0.06–0.11)	0.08 (0.05–0.12)	0.13 (0.05–0.18)	0.06 (0.01–0.26)
PPDS	49 (7.7)	0.05 (0.03–0.08)	0.09 (0.06–0.15)	0.09 (0.04–0.20)	0.13 (0.04–0.38)
Hispanic (n = 471)		**Class 1: no discrimination**	**Class 2: general discrimination**	**Class 3: other discrimination**	**Class 4: compound discrimination**
APHOs	117 (24.8)	0.27 (0.22–0.33)	0.21 (0.15–0.29)	0.23 (0.09–0.46)	0.21 (0.06–0.54)
PTB	35 (7.8)	0.07 (0.05–0.11)	0.07 (0.04–0.14)	0.15 (0.05–0.39)	0.07 (0.01–0.47)
Apgar <7	22 (4.8)	0.05 (0.03–0.08)	0.02 (0.00–0.09)	0.14 (0.04–0.36)	0.15 (0.04–0.47)
White (n = 853)		**Class 1: no discrimination**	**Class 2: general discrimination**	**Class 3: education, income, weight, appearance, age discrimination**	**Class 4: compound discrimination**
APHOs	252 (29.5)	0.28 (0.25–0.34)	0.35 (0.29–0.40)	0.17 (0.06–0.41)	0.12 (0.04–0.30)
LBW	58 (7.7)	0.06 (0.04–0.09)	0.11 (0.08–0.15)	0.04 (0.00–0.39)	0.02 (0.00–0.33)
SGA	105 (14.0)	0.14 (0.11–0.18)	0.17 (0.13–0.22)	0.01 (0.00–0.97)	0.07 (0.02–0.26)
Apgar <7	50 (6.1)	0.06 (0.04–0.08)	0.07 (0.04–0.11)	0.08 (0.02–0.28)	0.02 (0.00–0.25)
Preeclampsia	62 (7.3)	0.07 (0.05–0.10)	0.08 (0.05–0.11)	0.07 (0.01–0.28)	0.07 (0.02–0.23)
PPDS	75 (9.3)	0.09 (0.07–0.14)	0.18 (0.13–0.25)	0.24 (0.09–0.49)	0.13 (0.04–0.34)

Abbreviations: APHOs, adverse perinatal health outcomes; BCH, Bolck, Croon and Hagenaars; LBW, low birthweight; NICU, neonatal intensive care unit; PPDS, postpartum depression symptoms; PTB, preterm birth; SGA, small for gestational age.

Table 5. Difference in Log Odds Estimations of Proportions of Outcomes, by Latent Class, Centering and Racial Disparities Study

Item	BCH-estimated difference in log odds (SE)					
	Class 2 vs class 1	Class 3 vs class 1	Class 4 vs class 1	Class 3 vs class 2	Class 4 vs class 2	Class 4 vs class 3
Overall						
APHOs	0.04 (0.11)	−0.05 (0.22)	0.98 (0.19)	0.91 (0.25)	0.93 (0.21)	1.02 (0.28)
PTB	0.29 (0.17)	−0.78 (0.55)	0.96 (0.32)	−0.06 (0.58)	0.68 (0.35)	1.74 (0.65)
LBW	0.16 (0.19)	0.21 (0.36)	1.29 (0.29)	1.05 (0.41)	1.14 (0.34)	1.09 (0.45)
SGA	−0.05 (0.15)	0.23 (0.26)	1.07 (0.24)	1.28 (0.31)	1.12 (0.27)	0.84 (0.35)
NICU	0.00 (0.40)	−0.35 (0.95)	1.07 (0.66)	0.65 (1.05)	1.07 (0.75)	1.42 (1.15)
Apgar <7	0.09 (0.16)	0.39 (1.18)	1.19 (0.34)	1.31 (0.43)	1.09 (0.06)	0.79 (0.19)
Preeclampsia	0.08 (0.19)	−0.74 (0.58)	1.27 (0.29)	0.18 (0.62)	1.19 (0.33)	2.01 (0.65)
PPDS	−1.36 (0.31)[a]	−0.63 (0.34)	0.18 (0.42)	1.73 (0.22)[a]	1.54 (0.34)	0.82 (0.36)
Black						
APHOs	0.99 (0.16)	0.14 (0.24)	1.24 (0.40)	0.15 (0.26)	0.25 (0.42)	1.11 (0.49)
PTB	1.09 (0.26)	−0.20 (0.45)	1.59 (0.53)	−0.29 (0.47)	0.51 (0.56)	1.79 (0.74)
LBW	1.23 (0.25)	0.07 (0.46)	1.83 (0.52)	−0.16 (0.43)	0.59 (0.54)	1.76 (0.70)
SGA	1.13 (0.19)	0.12 (0.29)	1.53 (0.46)	−0.01 (0.32)	0.39 (0.48)	1.41 (0.58)
NICU	1.04 (0.67)	0.59 (0.84)	2.37 (0.93)	0.55 (0.92)	1.33 (1.04)	1.77 (1.25)
Apgar <7	1.19 (0.28)	0.38 (0.39)	0.78 (0.94)	0.18 (0.42)	−0.41 (0.97)	0.41 (1.07)
Preeclampsia	0.91 (0.28)	0.22 (0.39)	0.55 (0.93)	0.31 (0.42)	−0.36 (0.96)	0.33 (1.06)
PPDS	1.74 (0.36)[b]	0.69 (0.53)	1.09 (0.75)	−0.05 (0.53)	0.35 (0.76)	1.39 (0.95)
Hispanic						
APHOs	−0.31 (0.27)	−0.23 (0.55)	0.69 (0.75)	0.08 (0.59)	1.00 (0.79)	0.92 (0.94)
PTB	−0.04 (0.45)	0.81 (0.69)	1.00 (1.25)	0.85 (0.79)	1.03 (1.31)	0.19 (1.43)
Apgar <7	−1.21 (1.05)	1.11 (0.71)	2.25 (0.86)	2.32 (1.29)	3.47 (1.37)	1.15 (1.08)
White						
APHOs	0.27 (0.17)	−0.65 (0.61)	−1.05 (0.58)	0.08 (0.65)	−0.31 (0.59)[b]	0.61 (0.83)
LBW	0.62 (0.30)[b]	−0.59 (1.48)	−1.24 (1.68)	−0.22 (1.54)	−0.86 (1.70)	0.36 (2.24)
SGA	0.25 (0.23)	−2.50 (3.92)	−0.70 (0.77)	−1.75 (3.97)	0.05 (0.79)	2.79 (4.02)
Apgar <7	0.22 (0.34)	0.34 (0.82)	−1.00 (1.41)	1.13 (0.91)	−0.22 (1.44)	−0.34 (1.61)
Preeclampsia	0.09 (0.31)	−0.04 (0.87)	0.04 (0.70)	0.88 (0.95)	0.95 (0.74)	1.08 (1.10)
PPDS	0.72 (0.29)[b]	1.10 (0.61)	0.35 (0.66)	1.38 (0.67)	0.63 (0.67)	0.25 (0.86)

Abbreviations: APHOs, adverse perinatal health outcomes; BCH, Bolck, Croon and Hagenaars; LBW, low birthweight; NICU, neonatal intensive care unit; PPDS, postpartum depression symptoms; PTB, preterm birth; SGA, small for gestational age.

[a] $P < .01$. P values determined by using Wald test.

[b] $P < .05$. P values determined by using Wald test.

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ORIGINAL RESEARCH

Association Between Lack of Access to a Neighborhood Park and High Blood Pressure in the Philadelphia Metropolitan Area

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PEER REVIEWED

Summary

What is already known on this topic?

Access to neighborhood green spaces such as parks may reduce high blood pressure.

What is added by this report?

Although lowered blood pressure is related to access to parks, not feeling comfortable visiting the park may negate its good effects.

What are the implications for public health practice?

Both having access to a nearby park and feeling safe and comfortable visiting that park may be important predictors of high blood pressure.

Abstract

Introduction

Studies have shown a lower risk of high blood pressure (HBP) among people who live near parks; however, little information exists on how feeling safe and comfortable visiting the park affects blood pressure. We identified associations between neighborhood park access, comfort visiting a park, and HBP to understand how these factors may contribute to disparities in HBP prevalence.

Methods

The 2018 Southeastern Pennsylvania Household Health Survey of 3,600 residents in the Philadelphia metropolitan area asked if respondents had ever been told they had HBP and whether they had a neighborhood park or outdoor space that they were comfortable visiting during the day. To assess the association between park access and HBP, we built multilevel logistic models to account for variation in HBP by zip code. We examined the effect modification of perceptions of park access (having a neighborhood park, not having a neighborhood park, or having a neighborhood park but not comfortable visiting it) and HBP by race, education, and poverty status.

Results

Both not having a neighborhood park and having a park but not feeling comfortable visiting it were associated with higher unadjusted odds of HBP, 70% and 90%, respectively, compared with having a neighborhood park. Adjusted odds ratios for the lack-of-park responses remained significant (no neighborhood park, adjusted odds ratio [aOR] = 1.4; 95% CI, 1.1–1.7; neighborhood park but not comfortable visiting, aOR = 1.4; 95% CI, 1.03–2.0). A significant gradient was observed for Black respondents compared with White respondents with odds of HBP increasing by perceptions of park access (aOR = 1.95 for people with a park; aOR = 2.69 for those with no park; aOR = 3.5 for people with a park that they are not comfortable visiting).

Conclusion

Even accounting for other risk factors for HBP, not having a neighborhood park or not feeling comfortable visiting one may influence individual HBP. Neighborhood factors that deter park access may contribute to racial disparities in HBP.

Introduction

Parks play a role in promoting physical activity and social connectedness within communities. Physical activity is essential for preventing and controlling risk factors and chronic diseases, such as diabetes, high blood pressure (HBP), cardiovascular disease (CVD), obesity, cancer, and depression (1). Likewise, social connectedness improves mental health, promotes healthy behaviors, and increases life expectancy (2,3). Studies have examined the presence of green spaces, including open-space parks, tree cover, and vegetation and their association with health outcomes. Some studies indicate that proximity to green spaces is linked to a lower risk of HBP, improved diabetes outcomes, and reduced obesity (4–8). However, people's use of parks depends on feeling safe and comfortable in their neighborhood. Studies have shown that factors such as the presence of walking paths and lighting, along with crime rates, can affect the use of parks for physical activity (9–13). No studies to date have evaluated the association between feeling comfortable visiting a park and the risk of chronic diseases such as HBP.

In the United States, race and socioeconomic status (SES) are risk factors for cardiovascular disease, and Black residents and those of lower SES have higher rates of HBP (14–16). Additionally, health disparities are evident in certain areas, such as historically redlined neighborhoods. Philadelphia County, Pennsylvania, has a lower health ranking than other counties of similar size, and its historically redlined neighborhoods continue to be racially segregated, have lower financial investment, and have worse health outcomes (17,18). For example, areas of primarily minority residents in Philadelphia have higher rates of diabetes, infant mortality, HBP, CVD deaths, and all-cause mortality compared with predominantly White areas and counties along Philadelphia County's border (19).

The concept of "equigenesis" (when something in the environment disrupts the usual relationship between economic disadvantage and a poor health outcome, making lower and higher economic status groups more equal) proposes that access to green spaces can reduce neighborhood health disparities (20). A recent study measured tree cover and vegetation by using both objective satellite imagery and perceived access through survey data from the Southeastern Pennsylvania Household Health Survey (SEPHHS). Perceived access was measured by using a question that asked participants whether there was a park in their neighborhood. Findings indicated that perceived access to green space was protective of HBP and had an equigenic effect in low-income neighborhoods (21). However, Koh et al (22) used the same data and did not observe such an effect on HBP disparities. Overall, green spaces such as neighborhood parks can reduce HBP, but questions remain about whether feeling comfortable and safe visiting a park is associated with a lower risk of HBP and whether parks can mitigate HBP disparities.

Our study focused on parks as green spaces and further examined the association between perceived park access, feeling comfortable visiting a park, and HBP. We also used individual-level data to explore any equigenic effects. We were interested in whether an equigenic effect was present among Black, low-income, or less educated participants in SEPHHS.

Methods

We used data from the 2018 SEPHHS, a cross-sectional, biennial health survey conducted via telephone (random-digit dialing), by using zip-code–stratified clusters, across southeastern Pennsylvania counties (Bucks, Chester, Delaware, Montgomery, and Philadelphia) (23). Response rates overall were 7.8% for cellular telephones and 6.3% for landlines and varied by source from 2% for random-digit dialing to 38% for re-contacts from past surveys (23). In 2018, the survey included a question about park access: "Is there a park or other outdoor space in your neighborhood that you're comfortable visiting during the day?" The 3 answer options were 1) "Yes, there is an outdoor space or park that you are comfortable visiting," 2) "No, there is no park in your neighborhood," or 3) "No, there is a park in your neighborhood, but you are not comfortable visiting it." The parks-access question was administered via Form A of the SEPHHS to half of the sampled survey participants, a total of 3,605 participants. HBP was determined by answers to the question, "Has a doctor ever told you that you have high blood pressure?" For the purposes of the current analysis, answers of "no" and "no, but borderline high or prehypertensive" were considered to indicate an absence of HBP, and "yes" indicated someone with HBP. To determine whether equigenic relationships were present, we evaluated the effect modification of HBP and park access by race, educational level, and poverty status (annual income above or below 150% of the federal poverty level). Institutional review board approval was not sought for this study because the data are archival and deidentified.

Statistical analysis

We used standard descriptive statistics to summarize continuous and categorical variables. We compared the demographics, comorbidities, and other characteristics of participants with HBP to those without HBP by using χ^2 tests of independence for categorical variables and 2-sample *t*-tests for continuous variables. We included variables that are identified in the literature as risk factors for HBP: age, sex, race (categorized as Black, White, or other), education level (less than high school graduate, high school graduate, some college, college graduate, or graduate school), poverty status, marital status (married, single, divorced, or widowed), and social capital (low, medium, high) (13,21,22). Social capital was measured with 5 questions about the characteristics of a participant's neighborhood; lower scores indicated less community togetherness and belonging. We categorized race into 3 categories because of the small number of participants who identified as neither White nor Black. We also used race as a social construct for racism, as a possible explanation for racial disparities in HBP prevalence. In addition, we added the following comorbidities:

diabetes, asthma, obesity, and any mental health disorder. These were marked as present if a participant indicated they had ever had the condition and included in analyses because they are associated with higher rates of HBP (24,25). Finally, to account for the effect of behaviors on HBP (25), we added 3 variables about smoking, diet, and exercise; whether a person had ever smoked; whether someone ate fruits and vegetables 0 to 2 times a day or 3 or more times a day; and whether they exercised at least 3 times a week.

We built logistic multilevel models with 2 levels, individual-level variables and zip code, to estimate the association between the perception of park access and HBP, with HBP as the dependent variable. Our analysis included several models: 1) the random-intercept or "empty" model with only zip code to assess the need for random effects (26), 2) a model that included only the park access variable, 3) a model that included all possible confounders (Table 1), and 4) the final model, which was built by using a backward selection method with Akaike information criterion and $P <$ .05 as a criterion for inclusion. The covariables included in the final model were age, sex, race, poverty status, education, ever-smoked, exercising 3 or more times per week, or a diagnosis of obesity, diabetes, asthma, or a mental health disorder. We then added interactions to the final model to estimate the effect modification between park access and race, education, and poverty status. These interactions were estimated in separate models to assess the effect modification of each variable without overfitting.

We used multilevel models to account for the clustering inherent in the sampling design and to model the variation in HBP odds ratios (ORs) that exists between zip codes in the Philadelphia metropolitan area (19). SEPHHS used a complex sampling scheme, with post-stratification weights to allow for population-average effects reporting and for projection to population totals. Following Snijders and Bosker, we treated the sampling design as ignorable or conditional upon our modeling of the effect of zip code, and included covariates that were used for post-stratification (27). This contrasts with previous studies using SEPHHS data (22) where the results were presented as population-average effects using generalized estimating equations. Our rationale for using model-based rather than design-based inference was twofold: 1) our interest was in actually modeling the variation of effects among zip codes, and 2) the distribution of SEPHHS data does not include probability weights, which are necessary for design-based inference in the multilevel modeling context.

All analyses were performed in Stata 17.0 (Statacorp, LLC). A value of $P <$.05 was considered significant, and 95% CIs were reported.

Results

Our population was predominantly older than 65 years (40.1%), female (58.6%), White (72.6%), married or partnered (53.3%), and had an annual income above 150% of the federal poverty level (78.6%). We saw significant differences between those who self-reported having and not having HBP. Among those who had access to a neighborhood park, 69.0% reported HBP, compared with 79.7% who reported not having HBP. A higher percentage of those with HBP were aged 65 years or older (57.2% with vs 28.3% without, $P < .001$), Black (27.9% with vs 15.5% without, $P < .001$), below 150% of the federal poverty level (27.9% with vs 16.8% without, $P < .001$), with diabetes (30.2% vs 8.0% without, $P < .001$), asthma (19.2% with vs 15.1% without, $P = .001$), a history of smoking (50.8% with vs 38.3% without, $P < .001$), with a diagnosed mental health disorder (21.1% with vs 16.5% without, $P < .001$), with obesity (41.2% with vs 24.2% without, $P < .001$), and with less than a high school education (6.8% with vs 2.9% without, $P < .001$) (Table 1). A lower percentage of those with HBP were married (47.8% married vs 57.1% without HBP, $P <$ .001), ate 3 or more servings of fruits and vegetables per day (60.1% yes vs 51.7% without HBP, $P < .001$), and exercised 3 or more days per week (48.9% with vs 62.0% without HBP, $P <$ .001).

Our random-intercept model confirmed significant variance among the zip codes in the odds of HBP (variance = 0.074, log likelihood test vs logistic [LR)] test $P < .001$). In the univariable model, those without a park had 68.0% higher odds of HBP (OR = 1.68; 95% CI, 1.4–2.0); those who had a park but were not comfortable visiting had 91% higher odds of HBP compared with those with a park (OR = 1.91; 95% CI, 1.5–2.5). After adjustment, the park categories remained significant: without a park, OR = 1.37; 95% CI, 1.1–1.7; with a park but not comfortable visiting, OR = 1.41; 95% CI, 1.03–2.0 (Table 2). Other significant variables in the final model included being aged 65 years or older (OR = 14.0; 95% CI, 9.1–21.4), of Black race versus White race (OR 2.0, 95% CI, 1.6–2.5), other race vs White (OR 1.45; 95% CI, 1.02–2.1), having diabetes (OR = 2.56; 95% CI, 2.1–3.2), asthma (OR = 1.26, 95% CI, 1.0–1.6), history of smoking (OR = 1.26; 95% CI, 1.1–1.5), having a mental health disorder (OR = 1.74, 95% CI, 1.4-2.2), or having obesity (OR = 2.0; 95% CI, 1.7–2.4). Higher education (college gradute or more) (OR = 0.63; 95% CI, 0.4–0.98) and exercising 3 or more times per week (OR = 0.79; 0.7–0.9) had lower odds of HBP.

Finally, the effect-modification analysis (Table 3) showed a strong effect for race and minimal effects for education or poverty levels. Compared with White participants with access to a park, White participants without a park had higher odds of HBP (OR = 1.39;

95% CI, 1.1–1.8), but those not comfortable visiting their park were not significantly different. We observed an increasing OR for Black participants with a park (OR = 1.95; 95% CI, 1.5–2.5), without a park (OR = 2.69; 95% CI, 1.8–4.1), and with a park but not comfortable visiting it (OR = 3.5; 95% CI, 2.0–6.2) compared with White participants with a park. Respondents of other races with a park had higher odds of HBP compared with White participants with a park (OR = 1.58; 95% CI, 1.04–2.4). The effect-modification analyses for education, poverty status, and park access revealed similar results to the main effects, and no clear pattern of effect. For instance, odds of HBP were higher for almost all categories where the group did not have a park or were not comfortable visiting the park, but the ORs were similar in magnitude. The one exception was among college graduates who had a park but were not comfortable visiting it had an OR of 2.2 (95% CI, 1.2–4.1) compared with college graduates with a park (Table 3).

Discussion

Proximity to green spaces, including parks, has been shown to have protective effects on HBP and other chronic health conditions. Our study supports these findings and additionally shows that feeling comfortable visiting a neighborhood park is also associated with HBP. Our findings that not having a park or not feeling comfortable visiting a park were both associated with higher odds of HBP imply that if residents do not feel comfortable visiting a neighborhood park, they may not access the health benefits associated with these green spaces. Our study adds to the results of existing studies that reported less park activity because of high crime or concerns about safety (9,12,13), but our study links these findings specifically to a higher risk of HBP.

We used multilevel models to account for the clustering present in the data. These also allowed for modeling the variance in the odds of HBP across zip codes in the Philadelphia area, in which we found significant variation. Unlike the Koh study (22), where population-average effects were presented, our reported effects represent the effect in a typical zip code (ie, one close to the mean on all measures). Though we found no evidence for modeling differences in the effects across zip code, our approach is informative for 2 reasons. First, failure to adjust for clustering in a sample leads to biased standard errors, which will in turn affect significance tests and CIs. Several methods allow for analyzing clustered data, and we chose multilevel modeling because we were interested in the distribution of effects across zip codes, rather than constructing a population average. Second, the advantage of our approach is it allows for interactions of variables across the levels of the design. For example, future work could examine whether zip codes with more or less green space have higher or lower ORs of HBP across racial categories. Though it is possible to test for such effects in population-average models, modeling the multilevel structure of the data yields a more nuanced understanding of such cross-level interactions (20). To fully account for the variation in HBP by zip code, future studies should include additional data aggregation with available zip-code–level variables (eg, available green space, access to healthy foods).

Despite the lack of zip-code–level predictors, we did perform several individual-level subgroup analyses to determine whether the effects of park access and perceptions of safety varied by race and SES. We found that for Black participants, the odds of HBP increased with a lack of park access and a perception of being uncomfortable visiting a neighborhood park. The odds of HBP for Black participants with a park were twice as high as for White participants with a park. Additionally, the odds of HBP for Black participants were 2.7 times higher with no park and 3.5 with a park but not feeling comfortable visiting it. Although these ratios indicate a racial disparity, the disparity is lessened by the presence of a park that participants are comfortable visiting. The effect-modification analysis for education and poverty status showed no clear pattern of modification. Most groups of similar education and poverty levels who did not have park access or were not comfortable visiting a park, had ORs of similar magnitude and were similar to the main effects. The one exception was a 2.2 times higher odds for college graduates with a park who were not comfortable visiting their park.

Our findings have some similarities with other studies that have used SEPHHS. Koh et al (22) found that odds of HBP decreased as education and age increased and were higher for Black than for White participants. They used objective measurements of tree-canopy cover and proximity to green spaces and found no effect modification in HBP disparity by levels of tree-canopy cover. This could have resulted from their choice of analysis, which did not model the multilevel nature of the data. Our study also showed a similar disparity in the odds of HBP across levels of education and park access. Knobel et al (21) found that perception of park access was protective of HBP for non-Hispanic Black participants. Our findings confirm this but add the effect modifications of park access and perceptions of safety.

Because historic redlining is associated with increased CVD (28), increased odds of HBP among Black participants with lower perceived access to parks elucidates a potential link to this practice. Redlining is responsible for racially segregated neighborhoods and de-investment in Black communities, and most Black residents in the Philadelphia metropolitan region live in racially segregated neighborhoods (18). These communities are also subject to the development of large industrial or business complexes and highways that decrease green spaces and are linked to higher CVD risk

(29). A recent study demonstrated that Black residents living in historically redlined neighborhoods had a higher prevalence of CVD risk factors, including HBP, than those living in nonredlined neighborhoods (30). Future studies are needed to research the relationship between redlined neighborhoods, green space access, and chronic disease. Multilevel modeling allows for better examination of these structural effects than population-average models.

In addition, the highest odds of HBP were observed among Black participants who had a park but were not comfortable visiting it. Although the survey did not ask why they were not comfortable, it could be because of feeling unsafe. A recent Gallup survey reported that Black Americans feel less safe in their communities compared with other racial groups, and, notably, 51% of Black women felt unsafe walking alone in their neighborhood (31). Feelings of being unsafe may contribute to allostatic load, a condition characterized by McEwen and Seeman (32) as the lifetime accumulation of stress that affects health. Allostatic load may come from stress due to trauma or abuse; environments like home, school, or neighborhoods; and for Black Americans, from experiences with discrimination (33). The lifetime stress experienced by Black Americans has been linked to the health disparities seen between Black and White Americans at younger ages and is independent of SES (33). Black participants who feel uncomfortable visiting a park in their neighborhood may be experiencing many other stressors that contribute to higher odds of HBP. Conversely, for Black participants who have a park in their neighborhood and feel comfortable visiting it, the odds of HBP are higher than for White participants with a park, but 1.5 times lower than those who have a park but do not feel comfortable visiting. This finding suggests that parks in a neighborhood and perceptions of safety may lessen health disparities for Black residents, which is evidence of an equigenic effect.

These findings could inform public health departments and organizations about additional avenues for reducing health disparities and HBP in general. Past studies have suggested that violent crime, lighting, broken glass, and busy roads are all concerns related to perceived safety and park use (9–13). Public health officials and city planners, working together, could create plans to alleviate these safety concerns. Providing park access to neighborhoods may also be an important mechanism for reducing HBP.

Our study had several limitations. First, it was a cross-sectional study that lacked temporality. We cannot say with certainty that perceptions of park access led to a reduction or increase in HBP. It is unknown whether a participant had HBP at the time of the study or whether they only had a history of HBP. We also do not know if those who answered “no” to having access to a park really did not have a park in their neighborhood. In addition, we can only make inferences about why participants did not feel comfortable visiting a park or outdoor space in their neighborhood. We can only generalize the results to people living in the Philadelphia metropolitan region, and the results do not represent changes that may have arisen because of the pandemic. In addition, some of the ORs were close to 1, which might be due to low numbers in some cells. The strengths of this study include the multilevel modeling that handled the clustered nature of observations by allowing variation in HBP by zip code and the number of confounders for which we controlled. We were also able to infer that not having a park or having a park but not feeling comfortable visiting it were both associated with higher odds of HBP; therefore, the physical presence of a park is not enough to encourage park visits. Thus, community planners should keep in mind perceptions of safety when planning new or evaluating existing green spaces.

Perceptions of park access are important for the health of people in a community. Our study showed an association between HBP and not having a park or having a park but not feeling comfortable visiting it. We observed an effect modification by race in which Black participants with a park, without a park, or with a park but not feeling comfortable visiting it had increased odds of HBP. Parks in neighborhoods can positively affect HBP, but addressing safety concerns and ensuring equitable access is essential to maximize their health-promoting potential.

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Tables

Table 1. Characteristics of Park Visitors (N = 3,605), by Blood Pressure (BP) Status, Southeastern Pennsylvania Household Health Survey, 2018

Characteristic	Normal BP, n (%) n = 2,131	High BP, n (%) n = 1,474	*P* value	Total, n (%) n = 3,605
Have park				
Yes	1,699 (79.7)	1,017 (69.0)	<.001	2,716 (75.3)
No	317 (14.9)	320 (21.7)		637 (17.7)
Yes, but not comfortable visiting	115 (5.4)	137 (9.3)		252 (7.0)
Age, y				
18–34	284 (13.3)	35 (2.4)	<.001	319 (8.9)
35–49	472 (22.2)	94 (6.4)		566 (15.7)
50–64	771 (36.2)	502 (34.1)		1,273 (35.3)
≥65	604 (28.3)	843 (57.2)		1,447 (40.1)
Sex				
Male	862 (40.5)	629 (42.7)	.18	1,491 (41.4)
Female	1,269 (59.5)	845 (57.3)		2,114 (58.6)
Race				
Black	323 (15.5)	399 (27.9)	<.001	722 (20.6)
White	1,604 (77.1)	942 (65.9)		2,546 (72.6)
Other	153 (7.4)	88 (6.2)		241 (6.9)
Annual income less than 150% of federal poverty level				
Yes	358 (16.8)	412 (27.9)	<.001	770 (21.4)
No	1,772 (83.2)	1,062 (72.1)		2,834 (78.6)
Comorbidities (yes only)				
Diabetes	170 (8.0)	442 (30.2)	<.001	612 (17.1)
Asthma	322 (15.1)	283 (19.2)	.001	605 (16.8)
Ever smoked	811 (38.3)	744 (50.8)	<.001	1,555 (43.4)
Mental health disorder	349 (16.5)	310 (21.1)	<.001	659 (18.4)
Obesity	497 (24.2)	586 (41.2)	<.001	1,083 (31.2)
Social capital				
Low	426 (22.3)	319 (25.3)	.09	745 (23.5)
Medium	1,009 (52.9)	663 (52.5)		1,672 (52.8)
High	472 (24.8)	280 (22.2)		752 (23.7)
Missing	224	212		436
Education				
Less than high school graduate	61 (2.9)	100 (6.8)	<.001	161 (4.5)
High school graduate, some college	902 (42.5)	793 (54.0)		1,695 (47.2)
College degree or more	1,160 (54.6)	576 (39.2)		1,736 (48.3)
Marital status				

(continued on next page)

(continued)

Table 1. Characteristics of Park Visitors (N = 3,605), by Blood Pressure (BP) Status, Southeastern Pennsylvania Household Health Survey, 2018

Characteristic	Normal BP, n (%) n = 2,131	High BP, n (%) n = 1,474	*P* value	Total, n (%) n = 3,605
Married or partnered	1,210 (57.1)	703 (47.8)	<.001	1,913 (53.3)
Single	470 (22.2)	298 (20.3)		768 (21.4)
Divorced or separated	196 (9.3)	179 (12.2)		375 (10.5)
Widowed	203 (9.6)	277 (18.8)		480 (13.4)
Other	40 (1.9)	14 (0.9)		54 (1.5)
Missing	12	3		15
Servings of fruit and vegetables per day				
0–2	1,081 (51.7)	865 (60.0)	<.001	1,946 (55.1)
≥3	1,011 (48.3)	576 (40.0)		1,587 (44.9)
Missing	39	33		72
Exercise ≥3 days per week	1,309 (62.0)	711 (48.9)	<.001	2,020 (56.6)
Missing	18	20		38

Table 2. Multilevel Models of the Association Between High Blood Pressure and Park Access Among Park Visitors (N = 3,605), Southeastern Pennsylvania Household Health Survey, 2018[a]

Fixed effects variable	Multivariable
Park access	
Yes, has park	1 [Reference]
No park	1.37 (1.1–1.7)
Yes, has park but not comfortable visiting	1.41 (1.03–2.0)
Age, y	
18–34	1 [Reference]
35–49	1.82 (1.1–2.9)
50–64	6.31 (4.1–9.6)
≥65	14.00 (9.1–21.4)
Female (vs male)	0.74 (0.6–0.9)
Race	
White	1 [Reference]
Black	2.00 (1.6–2.5)
Other	1.45 (1.02–2.1)
Annual income less than 150% of federal poverty level	1.26 (1.02–1.5)
Comorbidities, yes	
Diabetes	2.56 (2.1–3.2)
Asthma	1.26 (1.0–1.6)
Ever smoked	1.26 (1.1–1.5)
Mental health disorder	1.74 (1.4–2.2)
Obesity	2.00 (1.7–2.4)
Education	
Less than high school graduate	1 [Reference]
High school graduate, some college	0.81 (0.5–1.2)
College graduate or more	0.63 (0.4–0.98)
Exercise ≥3 days per week	0.79 (0.7–0.9)

Abbreviation: LR, log likelihood test versus logistic model.
[a] Values are odds ratio (95% CI). Random effects for zip code were zero for variance and LR.

Table 3. Effect Modification of Association Between High Blood Pressure and Park Access Among Park Visitors (N = 3,605), by Race, Education, and Poverty Status[a], Southeastern Pennsylvania Household Health Survey, 2018

Variable	Has park	No park	Has park but not comfortable visiting
Race			
Black	1.95 (1.5–2.5)	2.69 (1.8–4.1)	3.5 (2.0–6.2)
White	1 [Reference]	1.39 (1.1–1.8)	1.3 (0.9–2.0)
Other	1.58 (1.04–2.4)	1.7 (0.8–3.6)	1.7 (0.7–4.1)
Education			
College graduate	1 [Reference]	1.5 (1.1–2.1)	2.2 (1.2–4.1)
High school graduate	1.4 (1.1–1.7)	1.8 (1.3–2.4)	1.7 (1.1–2.5)
Less than high school graduate	1.9 (1.1–3.4)	2.0 (0.9–4.1)	1.7 (0.5–5.4)
Annual income less than 150% of federal poverty level			
No	1 [Reference]	1.4 (1.1–1.8)	1.6 (1.1–2.4)
Yes	1.3 (1.1–1.7)	1.6 (1.1–2.4)	1.6 (0.9–2.6)

[a] Adjusted for age, sex, race, poverty status, diabetes, asthma, ever smoked, mental health, education, exercise, zip code. Values are odds ratio (95% CI).

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ORIGINAL RESEARCH

Impact of Geography and Rurality on Preconception Health Status in the United States

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PEER REVIEWED

Summary

What is already known on this topic?

Maternal health is in crisis in the United States with many preventable maternal deaths. Preconception health influences maternal health.

What is added by this report?

Sociodemographic factors, particularly rurality and region, are related to preconception health. Our study was the first individual-level analysis of a preconception health-risk index for the United States.

What are the implications for public health practice?

The impact of social determinants of health on preconception health needs should be recognized and addressed along with preventive care programming in this understudied area.

Abstract

Introduction

Maternal illness and death are largely preventable; however, the field of preconception health needs further study. Geographic region and rurality play a large role in maternal health, and an understanding of the effect of these 2 factors at the individual level could prevent future adverse maternal health outcomes.

Methods

We developed an abbreviated index of preconception health risk (diabetes, hypertension, body weight, mental health, unintended pregnancy, HIV, alcohol and nicotine use, nutrition, physical activity, receipt of the influenza vaccine) by using data from the 2019 Behavioral Risk Factor Surveillance System (BRFSS). A score of 1 was assigned for each behavior factor classified as unhealthy and a score of 0 for each factor classified as healthy, for a total potential score of 11. Respondent women from the 37 states that included the BRFSS family planning supplemental module who were aged 18 to 44 years who could become pregnant (N = 25,999) were included. We used univariate and multivariate regression models to assess the relationship between sociodemographic factors (age, race or ethnicity, relationship status, insurance status, education, income, and rurality and region) and preconception health, with a primary focus on rurality and region.

Results

The average preconception health risk index score among participants was 3.5, with higher average scores in rural areas than in urban areas. All factors were independently associated with preconception health. Compared with women living in the urban Northeast, women living in all rural and region groups, except the rural West, had increased preconception health risk.

Conclusion

Preconception health scores from our study showed that, on average, a person had more than 3 risk factors or behaviors. Given the current state of reproductive health policy in the United States, increased efforts are needed to address preconception health.

Introduction

Maternal health remains a significant problem in the United States. Awareness is increasing of the need for preconception health care — preventive health care before a person becomes pregnant — as a means of reducing the risk of maternal illness and death. The leading cause of pregnancy-related death from 2017 through 2019 was mental health conditions, followed by hemorrhage and preexisting cardiac and coronary conditions (1). Both the first and third leading causes of death are linked to preconception health and are conditions that can be managed before pregnancy (1–3). Although prior studies in Canada (4) and Singapore (5) have used a composite index to examine preconception health risk among either their general populations (4) or those currently trying to conceive (5), studies have not examined this risk in the United States.

Prior research has pointed to geographic location, particularly rurality, as a social determinant of health that affects maternal illness and death, an area that needs further research (6). Geographic location determines place-based factors, such as access to transportation, housing, food, and health care and exposure to environmental conditions, such as violence and air and water quality, all of which can affect maternal health. Geographic location is important to examine in light of the disparities in maternal illness and death based on geographic location (6). Compared with pregnant urban dwellers with similar sociodemographic and medical backgrounds, pregnant rural dwellers have an increased risk of illness and death (7). Pregnant people who live in rural areas are 5 times more likely to live in a county that has a very high maternal vulnerability score compared with those residing in urban areas (8). People with preconception chronic conditions are more likely to reside in low-income rural areas than their urban counterparts (9). The South and Midwest have the highest levels of maternal vulnerability, indicating an increased risk for adverse birth outcomes in these regions (8). Measures, such as the maternal vulnerability index (8) that analyze systems-level preconception health indicators and studies that examine preconception health risk factors independently of one another (10,11) are both needed. However, an analysis is also needed at the individual level of composite preconception health status to better understand the health of women who make up these US counties, states, and regions. Our objective was to assess preconception health status in the United States and how rurality and regional residence affect it.

Methods

Data source

We analyzed cross-sectional data from the 2019 Behavioral Risk Factor Surveillance System (BRFSS) (12) to create a composite index to assess preconception health in rural areas. BRFSS is a national ongoing survey of noninstitutionalized adults conducted by state health departments in collaboration with the Centers for Disease Control and Prevention (12). Along with the general survey, which is distributed in all 50 states and participating territories, states and territories can elect to include various supplemental modules (12). Our analysis was limited to the 37 states that administered the family planning supplemental module to eligible respondents who were female, aged 18 to 49 years, not pregnant, and had not had a hysterectomy (N = 39,047). We excluded women aged 45 to 49 years (n = 8,397) and those who responded to the family planning module but indicated they were pregnant (n = 93) or used a permanent form of birth control (n = 3,953). Respondents with unknown or missing values for any of the covariates, except for income, were also excluded (n = 605). Respondents missing values for income (n = 3,560) were retained. Our final analytic sample totaled 25,999.

Measures

We developed an abbreviated preconception health risk index (aPHRI) following recommendations from the American Academy of Family Physicians (AAFP) (2) and the American College of Obstetrics and Gynecology (ACOG) (3) for preconception health. The index included all indicators measurable through BRFSS data (13) (Table 1). For each measure of risk reported (either healthy [0] or unhealthy [1]), a score of 1 was added to the total score, for a potential total aPHRI score of 11. Any of these independent risks can harm a person's reproductive health or potential future pregnancy; therefore, any respondent with a score above zero was considered to be at preconception health risk. A higher score indicated a higher preconception health risk. Spearman correlations between risk measures were all below 0.2.

We assigned states to regions based on the most recent census region classifications (15). The regional representation in this subsample was 14 states in the Southern region (Alabama, Arkansas, Delaware, Florida, Georgia, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Virginia, and West Virginia), 5 in the Northeast region (Connecticut, Massachusetts, New York, Pennsylvania, and Rhode Island), 10 in the Midwest region (Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, Ohio, South Dakota, and Wisconsin), and 8 in the Western region (Arizona, Idaho, Hawaii, Montana, New Mexico, Oregon, Utah, and Wyoming). The regions were then further divided into rural and urban categories based on the BRFSS classification for a total of 8 rural regions (urban South, rural South, urban Northeast, rural Northeast, urban Midwest, rural Midwest, urban West, and rural West) (12).

We included sociodemographic and socioeconomic covariates in our analysis. The sociodemographic covariates were race or ethnicity (non-Hispanic American Indian or Alaska Native, non-Hispanic Asian, non-Hispanic Black, Hispanic, non-Hispanic White, non-Hispanic Native Hawaiian or Pacific Islander, non-Hispanic multiracial, non-Hispanic other race), annual household income from all sources (<$15,000; $15,000–$24,999; $25,000–$34,999; $35,000–$49,999; ≥$50,000, missing). Socioeconomic covariates were insurance status (insured or uninsured), age (18–24 y, 25–34 y, 35–44 y), education status (did not graduate from high school, graduated from high school, attended college or technical school, graduated from college or technical school), and relationship status (in a married or unmarried relationship or not in a relationship).

Analysis

We followed univariate and bivariate analyses with linear regression. Models were built sequentially. First, each covariate was included, one at a time (unadjusted models); then, all covariates except for socioeconomic factors (insurance status, education, and income) were included (sociodemographic model). Last, a final model was run that included all covariates. Significance was determined by a value of $P < .05$. We used SAS software version 9.4 (SAS Institute Inc) for all data analyses. All analyses were weighted and adjusted for the complex sample design.

Results

Only 6.5% of respondents lived in rural areas (Table 2), and the highest proportion of those rural women lived in the South (45.3%) versus the Northeast (6.4%). Rural areas in all geographic regions showed higher aPHRI scores than their urban counterparts, and geographic regions differed, with the highest means in the South and Midwest and the lowest in the Northeast.

The largest age group was women aged 25 to 34 years (36.9%) and the largest racial or ethnic group was non-Hispanic White (58.7%). Of all other racial and ethnic groups, 17.0% of participants identified as non-Hispanic Black, 15.8% identified as Hispanic, 4.7% identified as non-Hispanic Asian, and 6.6% or less were from the remaining groups (non-Hispanic American Indian or Alaska Native, non-Hispanic multiracial, non-Hispanic Native Hawaiian or Pacific Islander, and non-Hispanic other race). Relationship status was nearly evenly distributed, and most respondents were insured (84.8%). Of the respondents, 34.0% attended some college or technical school, and 30.6% reported graduating from college or technical school; only 9.8% had not graduated from high school. Forty percent reported an annual household income of $50,000 or more, and 22.3% had an annual income less than $25,000. Income was missing for 16.2%.

Women aged 25–44 years had higher aPHRI scores than women aged 18–24. By race or ethnicity, respondent aPHRI scores were as follows: non-Hispanic American Indian, 4.01; non-Hispanic Black, 3.88; non-Hispanic multiracial, 3.77; non-Hispanic Native Hawaiian or Pacific Islander, 3.98; and non-Hispanic other race, 3.81. All the foregoing had higher mean aPHRI scores than participants who identified as Hispanic, 3.55; non-Hispanic White, 3.48, or non-Hispanic Asian, 2.96. Respondents who were not in a relationship (3.67) or were uninsured (3.91) had a higher mean aPHRI score than those in a relationship or insured. Respondents with lower incomes or education had higher aPHRI scores than those with higher incomes or education.

The most prevalent preconception health risk factors and behaviors in the total sample by aPHRI score were poor nutrition (87.0%), not having had an influenza vaccination (60.5%), and unhealthy weight (55.9%) (Table 3). This was consistent across all rurality and region groups except for the rural Northeast, where the third most prevalent component was risk of unintended pregnancy (53.2%) compared with 28.6% overall. In most cases, the prevalence of each component was higher among rural women than urban women in each region. The greatest disparities in prevalence by rurality and region were related to risk of unintended pregnancy between the urban West and rural Northeast (25.4% vs 53.2%), nicotine use between the urban West and rural Northeast (11.6% vs 37.1%), and heavy alcohol use (drinking more than 7 drinks in a week or 4 drinks on a single occasion in the past 30 days) between the rural South and the urban Midwest (12.2% vs 24.5%).

All variables were significant when run in separate regression models examining composite aPHRI scores (Table 4). By rurality and region, when compared with residing in the urban Northeast, women residing in all other areas except for the urban West or rural Northeast had significantly higher aPHRI scores. By race and ethnicity, when compared with non-Hispanic White, American Indian or Alaska Native, Black, multiracial, and non-Hispanic Native Hawaiian or Pacific Islander women had significantly higher aPHRI scores. Non-Hispanic Asian women had significantly lower scores. Women aged 18 to 24 years had significantly lower aPHRI scores than women aged 35 to 44 years, and women who were not in a relationship had higher aPHRI scores than women in a relationship. Women with lower incomes or education or who were not insured also had significantly higher aPHRI scores than their respective reference groups. Results were generally similar in the sociodemographic model. In the final model, including socioeconomic variables, being non-Hispanic and residing in the rural West or self-identified as multiracial were no longer significant. Hispanic women had significantly lower aPHRI scores compared with non-Hispanic White women. All socioeconomic variables, except for missing income data, remained significantly associated with aPHRI score.

Discussion

As the first composite, individual-level measurement of preconception health in the United States, our study assesses its status. Although prior studies have analyzed preconception health factors independently (10,11) or at a community level (5), no study has examined cumulative, individual-level risk factors. The aPHRI scores in our overall study sample, and particularly the scores found in rural areas, show the need to address preconception health issues to prevent or reduce adverse maternal health outcomes. The aPHRI score reflects the number of risk factors and behaviors an individual has, meaning that on average a woman in the United States has 3.6 risk factors or behaviors that could put her at increased risk for adverse maternal health outcomes, particularly residents of rural areas. It should be noted that only 6.5% of our sample resided in a rural area.

In addition to the already high mean aPHRI score, especially in a relatively young population-based sample, large disparities occurred in mean aPHRI scores across all sociodemographic and socioeconomic factors analyzed. Disparities existed by rurality and region and by age, race or ethnicity, relationship status, insurance status, education, and income, with the lowest mean scores among non-Hispanic Asian women (2.96) and the highest among women with an annual household income lower than $15,000 (4.06). Furthermore, all variables were found to be independently associated with the aPHRI score, building on existing literature that has shown that rurality, region, race and ethnicity, age, and insurance status all affect preconception (8,16) and maternal health (6–8). Historically, social determinants of health have been linked to access to and receipt of adequate health care (17), and this extends to preconception health. Prevention efforts should recognize and address the impact of social determinants of health on preconception health and, ultimately, maternal health.

The South and Midwest had the highest mean aPHRI scores, and both the South (8,16) and Midwest (8) have previously been identified as having worse preconception health than other regions. This comes as no surprise, because all but 2 of the states we studied in these regions had expanded Medicaid at the time the data used in this analysis were collected. Seven of the 12 Southern states and 7 of the 12 Midwestern states included in our analysis did not have expanded Medicaid and had the highest average aPHRI scores (18). We found a significant association between insurance status and aPHRI score. Private health care practices and clinics could include preconception health screenings and interventions during routine general and women's health appointments (19), particularly preconception health interventions that are culturally appropriate and address geographic, cultural, and sociodemographic differences (20). Recognizing that the groups at highest preconception health risk are often those without access to consistent health care, large systems-level changes need to be made.

More than three-quarters of our sample population had poor nutrition, and more than half had an unhealthy body weight or had not received an influenza vaccination. This was consistent in all rural and urban areas except the rural Northeast where the risk of unintended pregnancy was the third most prevalent aPHRI factor. An estimated 69% of US women do not fall within a healthy range according to the body mass index (weight in kg divided by height in m^2) (21), and an increase in the prevalence of pre-pregnancy obesity has been reported (22). Only 36% of adults aged 18 to 49 years received an influenza vaccination in the 2022–2023 season (23). Overall, 14.5% of women met the daily fruit consumption recommendations in 2019, and 12.4% met the daily recommendations for vegetables (24). These numbers are all within a range similar to what we found in our study. All the factors and behaviors our study analyzed were based on ACOG and AAFP assessments, which indicates that unhealthy preconception status leads to increased risk for adverse maternal health outcomes (7,8).

Across all groups, the lowest prevalence of risk, 25.4% for unintended pregnancy, was in the urban West, indicating that across all rurality and region groups, at least 1 in 4 women were at risk for an unintended pregnancy. However, all rural groups had a higher prevalence of unintended pregnancy compared with urban groups where nearly 1 in 3 women were at risk for an unintended pregnancy. The prevalence of risk for unintended pregnancy in the overall sample population was 28.6%. These high rates further emphasize the critical need to address preconception health risk factors and behaviors before a person becomes pregnant to prevent adverse maternal health outcomes, particularly in rural areas. In 2017, when there was still a federal legal right to abortion in the United States, state-level data indicated that 16% to 59% of unwanted pregnancies were terminated (25). With federal protection no longer in place and abortion illegal in nearly half of all states, more unwanted pregnancies are being carried to term (26). The results of this study add to the existing literature to emphasize the need to address the concerning rates of preconception health in the United States as a whole (7,8), and specifically in rural areas (5). Consistent with prior literature, rural residents in our study had high rates of preconception health risks (27). Given the current status of reproductive health policy in the United States, the high number of our study participants at risk for an unintended pregnancy, the high aPHRI scores overall found in this study, and the impact of sociodemographic and socioeconomic factors on aPHRI scores, increased preventive preconception health care is needed now (28).

Limitations

Our study had several limitations. First, the data used were self-reported. Second, the stigma surrounding mental health conditions and substance use likely caused participants to underreport their mental health status and nicotine and alcohol use. However, despite assumed underreporting, we found a high prevalence of these 3 factors. Third, the awareness of conditions such as diabetes and hypertension rely on a medical diagnosis and are contingent on a person having access to appropriate medical care. This likely contributed to underreporting of pregestational diabetes and hypertension seen in our results, particularly in rural areas. Prior studies have estimated the prevalence of pregestational hypertension and diabetes among women of reproductive age to be 9.3% and 4.5%, respectively, with nearly 17% of those with hypertension and 30% of those with diabetes unaware of their condition (29). Fourth, our results are not generalizable to all women. Our study was limited to 37 states that completed the BRFSS family planning module. BRFSS also had varying response rates by state. Complex survey weights were employed to increase generalizability. Most of the youngest women in our sample would not have had the opportunity to complete the highest level of education we measured. Lastly, although the measures included in aPHRI have been linked to maternal health outcomes, the index as a whole has not been validated. A validated composite measure of preconception health is needed to examine preconception health status in the United States over time. Despite these limitations, our study illustrates the relationship between sociodemographic and socioeconomic factors and preconception health.

Conclusion

Our aPHRI analysis provides an overview of the current state of preconception health in the United States and the differences that exist by rurality and region. This overview is especially timely given the recent restriction to reproductive health care resulting from the Dobbs vs Jackson Women's Health Organization decision, removing the constitutional right to abortion (30). It is more critical now than ever to address preconception health in an effort to prevent adverse maternal health outcomes. To address the preconception health needs of people able to become pregnant continued examination of best practices is needed to consider rural and geographic group status, along with other social determinants of health, specifically increasing access to health care. Although our study examines preconception health, which is focused on the health of people who may be able to become pregnant, preconception health is only one component of reproductive health. Reproductive health as a whole should be available to all people, regardless of the desire to become pregnant or fertility status.

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Tables

Table 1. Components of the Abbreviated Preconception Health Risk Index, 2019 Behavioral Risk Factor Surveillance System (BRFSS), 37 states

Index component	BRFSS measure of risk
Health factors	
Pre-gestational diabetes	Told by a doctor, nurse, or other health professional they have diabetes, not including during pregnancy (3).
Pre-gestational hypertension	Told by a doctor, nurse, or other health professional they have high blood pressure, not including during pregnancy (3).
Weight	Body mass index (weight in kg divided by height in m^2) score was other than normal (18.5–24.9), based on self-reported height and weight (2,3).
Mental health	Mental health was self reported to be "not good" 14 or more days in the last month (2,3).
Health behaviors	
Risk of unintended pregnancy	Currently sexually active, not using contraception, and not reporting any of the following: "don't care if you get pregnant," "you want a pregnancy," or "same sex partner" (People who were currently pregnant or had a hysterectomy or tubal ligation were excluded from the study.) (2,3).
Risk of HIV and HIV screening	Answering yes when asked if any of the following situations apply to you: You have injected any drug other than those prescribed for you in the past year. You have been treated for a sexually transmitted disease in the past year. You have given or received money or drugs in exchange for sex in the past year. You had anal sex without a condom in the past year. You had 4 or more sex partners in the past year. And yes to the question, "Including fluid testing from your mouth, but not including tests you may have had for blood donation, have you ever been tested for HIV?" which indicates engaging in behaviors that put them at risk for contracting HIV in the past year and never tested for HIV (2,3).
Heavy alcohol use	Drinking more than 7 drinks in a week or 4 drinks in a single time period in the past 30 days (2,3).
Nicotine	Currently smoking cigarettes (2,3).
Nutrition	Eating fewer than 1.5 servings of fruit, or fewer than 2.5 servings of vegetables (if aged 31 or younger), or fewer than 2 servings of vegetables (if older than 31) daily (3,14).
Physical activity	Doing less than 150 min of physical activity in a week on average in the past month (3).
Influenza vaccine	Had not received an influenza vaccine in the past year (3).

Table 2. Characteristics of People Who May be Able to Become Pregnant and Adjusted Mean Abbreviated Preconception Health Risk Index (aPHRI) Scores, Behavioral Risk Factor Surveillance System, 2019, N = 25,999

Characteristic	N (%)[a]	Mean aPHRI Score (SE)
Total population		
Urban	22,881 (93.5)	3.53 (0.01)
Rural	3,118 (6.5)	3.80 (0.03)
Rurality and region		
South	8,752 (39.1)	3.67 (0.02)
Urban	7,728 (92.5)	3.65 (0.02)
Rural	1,024 (7.5)	3.93 (0.05)
Northeast	3,038 (22.2)	3.34 (0.03)
Urban	2,992 (98.1)	3.33 (0.03)
Rural	46 (1.9)	3.89 (0.22)
Midwest	8,403 (28.5)	3.58 (0.02)
Urban	7,027 (91.0)	3.57 (0.02)
Rural	1,376 (9.0)	3.69 (0.04)
West	5,806 (10.3)	3.42 (0.02)
Urban	5,134 (93.5)	3.41 (0.02)
Rural	672 (6.5)	3.61 (0.06)
Age, y		
18–24	5,358 (29.1)	3.40 (0.02)
25–34	9,547 (36.9)	3.61 (0.02)
35–44	11,094 (33.9)	3.61 (0.01)
Race or ethnicity		
Non-Hispanic American Indian or Alaska Native	545 (1.0)	4.01 (0.07)
Non-Hispanic Asian	830 (4.7)	2.96 (0.05)
Non-Hispanic Black	3,002 (17.0)	3.88 (0.03)
Hispanic	3,383 (15.8)	3.55 (0.02)
Non-Hispanic White	17,053 (58.7)	3.48 (0.01)
Non-Hispanic multiracial	851 (2.1)	3.77 (0.05)
Non-Hispanic Native Hawaiian or Pacific Islander	198 (0.5)	3.98 (0.11)
Non-Hispanic other race	137 (0.3)	3.81 (0.15)
Relationship status		
In a married or unmarried relationship	12,402 (47.4)	3.41 (0.01)
Not in a relationship	13,597 (52.6)	3.67 (0.01)
Insurance status		
Insured	22,358 (84.8)	3.48 (0.01)
Uninsured	3,641 (15.2)	3.91 (0.02)
Education		
Did not graduate high school	1,527 (9.8)	3.91 (0.04)
Graduated high school	5,805 (25.7)	3.80 (0.02)

[a] Percentages are weighted.

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Table 2. Characteristics of People Who May be Able to Become Pregnant and Adjusted Mean Abbreviated Preconception Health Risk Index (aPHRI) Scores, Behavioral Risk Factor Surveillance System, 2019, N = 25,999

Characteristic	N (%)[a]	Mean aPHRI Score (SE)
Attended college/technical school	7,961 (34.0)	3.66 (0.02)
Graduated college/technical school	10,706 (30.6)	3.10 (0.01)
Annual income from all sources, $		
<15,000	2,122 (8.6)	4.04 (0.03)
15,000–24,999	3,606 (14.7)	4.01 (0.02)
25,000–34,999	2,158 (8.8)	3.79 (0.03)
35,000–49,999	3,126 (11.8)	3.77 (0.03)
≥50,000	11,427 (40.0)	3.23 (0.01)
Missing	3,560 (16.2)	3.38 (0.02)

[a] Percentages are weighted.

Table 3. Prevalence of Abbreviated Preconception Health Risk Index Factors and Behaviors, by Rurality and Region Group, Among Participants (N = 25,999), Behavioral Risk Factor Surveillance System, 2019[a]

Risk factor	Total population prevalence, %	South		Northeast		Midwest		West	
		Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Pregestational diabetes	3.0	3.5	4.1	2.4	0.0	2.6	2.5	3.5	2.8
Pregestational hypertension	11.0	13.5	13.4	8.8	9.6	9.7	7.7	9.5	10.0
Unhealthy weight[b]	55.9	57.5	66.8	52.4	49.6	56.1	58.4	54.0	56.2
Poor mental health	19.6	20.1	19.9	17.8	26.6	20.2	20.1	20.2	19.9
Risk of unintended pregnancy	28.6	29.8	36.6	27.0	53.2	27.9	32.6	25.4	30.9
Risk of HIV, HIV screening[c]	2.8	2.9	2.7	2.6	1.9	3.0	1.5	3.4	2.9
Heavy alcohol use[d]	20.6	19.3	12.2	21.0	20.1	24.5	18.3	17.5	19.0
Nicotine use[e]	14.8	15.1	23.8	12.7	37.1	15.2	22.3	11.6	17.2
Poor nutrition[f]	87.0	87.4	89.5	84.7	86.4	88.1	86.2	86.8	89.2
Poor physical activity[g]	51.0	51.1	54.5	50.2	49.5	52.8	53.3	46.3	43.6
No influenza vaccine	60.5	65.2	66.7	53.6	55.3	57.5	66.1	63.3	68.8

[a] Values are percentages.
[b] Body mass index (weight in kg divided by height in m^2) score other than normal (18.5–24.9) based on self-reported height and weight.
[c] Answering yes when asked if any of the following situations apply: have injected any drug other than those prescribed in the past year, have been treated for a sexually transmitted disease in the past year, have given or received money or drugs in exchange for sex in the past year, had anal sex without a condom in the past year, had 4 or more sex partners in the past year, and answering yes to the question, "Including fluid testing from your mouth, but not including tests you may have had for blood donation, have you ever been tested for HIV?" which indicates engaging in behaviors that put a person at risk for contracting HIV in the past year but never tested for HIV (2,3).
[d] Drinking more than 7 alcoholic drinks in a week or 4 drinks on a single occasion in the past 30 days (2,3).
[e] Currently smoking cigarettes (2,3).
[f] Eating fewer than 1.5 servings of fruit or 2.5 servings of vegetables daily (if aged 31 years or younger), or fewer than 2 servings of vegetables daily if older than 31 years (3,14).
[g] Doing less than 150 min of physical activity on average in a week in the past month (3).

Table 4. Associations Between Demographic and Socioeconomic Factors and Abbreviated Preconception Health Risk (aPHRI) Index, Behavioral Risk Factor Surveillance System, 2019, N = 25,999

	Unadjusted models		Sociodemograhic model		Final model	
Demographic	Beta (SE)	*P* value[a]	Beta (SE)	*P* value[b]	Beta (SE)	*P* value[c]
Rurality and region						
Urban Southeast	.104 (.045)	<.001	.082 (.052)	<.001	.060 (.050)	<.001
Rural Southeast	.068 (.078)	<.001	.062 (.077)	<.001	.039 (.076)	<.001
Urban Northeast	Reference					
Rural Northeast	.024 (.291)	.05	.024 (.271)	.04	.018 (.248)	.09
Urban Midwest	.072 (.053)	<.001	.072 (.052)	<.001	.053 (.050)	<.001
Rural Midwest	.038 (.083)	<.001	.043 (.082)	<.001	.027 (.078)	.001
Urban West	.016 (.057)	.15	.017 (.057)	.12	.006 (.055)	.60
Rural West	.014 (.102)	.007	.012 (.102)	.02	.005 (.101)	.36
Age, y						
18–24	−.065 (.042)	<.001	−.113 (.044)	<.001	−.154 (.045)	<.001
25–34	−.000 (.037)	.98	−.018 (.036)	.13	−.040 (.035)	<.001
35–44	Reference					
Race or ethnicity						
Non-Hispanic American Indian	.036 (.124)	<.001	.032 (.129)	<.001	.016 (.120)	.05
Non-Hispanic Asian	.075 (.102)	<.001	.069 (.099)	<.001	.055 (.094)	<.001
Non-Hispanic Black	.101 (.047)	<.001	.076 (.049)	<.001	.046 (.047)	<.001
Hispanic	.017 (.049)	.15	.022 (.049)	.07	.047 (.052)	<.001
Non-Hispanic multiracial	.027 (.126)	.02	.027 (.120)	.02	.021 (.117)	.06
Non-Hispanic Native Hawaiian or Pacific Islander	.017 (.214)	.02	.019 (.209)	<.001	.014 (.194)	.04
Non-Hispanic White	Reference					
Non-Hispanic other race only	.015 (.227)	.14	.011 (.230)	.28	.009 (.221)	.35
Relationship status						
In a relationship	Reference					
Not in a relationship	.086 (.033)	<.001	.113 (.035)	<.001	.069 (.036)	<.001
Insurance status						
Insured	Reference		Not included in model		Reference	
Not Insured	.103 (.046)	<.001			.049 (.047)	<.001
Education status						
Did not graduate high school	.163 (.068)	<.001	Not included in model		.123 (.072)	<.001
Graduated high school	.205 (.042)	<.001			.166 (.045)	<.001
Attended college or technical school	.179 (.037)	<.001			.148 (.039)	<.001
Graduated college or technical school	Reference				Reference	
Annual income, $						

[a] *P* values were determined from univariate linear regression analyses of composite aPHRI scores.
[b] *P* values were determined from the sociodemographic multivariate regression analysis of composite aPHRI scores, excluding socioeconomic factors.
[c] *P* values were determined from the final multivariate regression analysis or composite aPHRI scores including socioeconomic factors.

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Table 4. Associations Between Demographic and Socioeconomic Factors and Abbreviated Preconception Health Risk (aPHRI) Index, Behavioral Risk Factor Surveillance System, 2019, N = 25,999

Demographic	Unadjusted models		Sociodemograhic model		Final model	
	Beta (SE)	*P* value[a]	Beta (SE)	*P* value[b]	Beta (SE)	*P* value[c]
<15,000	.153 (.059)	<.001	Not included in model		.092 (.066)	<.001
15,000 to 24,999	.185 (.048)	<.001			.118 (.054)	<.001
25,000 to 34,999	.107 (.058)	<.001			.064 (.062)	<.001
35,000 to 49,999	.117 (.054)	<.001			.085 (.054)	<.001
≥50,000	Reference				Reference	
Income missing	.038 (.048)	.002			.002 (.054)	.87

[a] *P* values were determined from univariate linear regression analyses of composite aPHRI scores.
[b] *P* values were determined from the sociodemographic multivariate regression analysis of composite aPHRI scores, excluding socioeconomic factors.
[c] *P* values were determined from the final multivariate regression analysis or composite aPHRI scores including socioeconomic factors.

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ORIGINAL RESEARCH

Engaging Students in Advancing Campus Tobacco-Free Policies: A Qualitative Study of California Community Colleges' Efforts

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PEER REVIEWED

Summary

What is known on this topic?

In 2021, young US adults had the highest smoking and vaping rates, and smoking prevalence is higher among community college students compared with their 4-year counterparts.

What is added by this report?

Student engagement is recognized as a key strategy in tobacco control policy efforts. However, research on community colleges and on student engagement in policy efforts is limited. This qualitative study describes the levels, roles, and value of engaging students in advancing a 100% tobacco-free policy in California community colleges.

What are the implications for public health practice?

Colleges should leverage their campuses' most important assets — students — as agents of change and involve them in the full spectrum of tobacco control efforts.

Abstract

Introduction

Tobacco use remains a serious problem for young adults. Given the large number of young adults attending college, a tobacco-free campus is one strategy to reduce tobacco use. Young adult engagement is recognized as a common strategic practice in tobacco control policy efforts, especially in changing social norms around tobacco use. Community colleges can leverage and engage students in adoption of campus 100% tobacco-free policies. This qualitative study examines the importance of student engagement in advancing 100% tobacco-free policies in community colleges and identifies strategies for campuses to involve students in such efforts.

Methods

We selected 12 community colleges and conducted key informant interviews with campus and community-based organizations that were involved in campus policy adoption efforts. We conducted 33 semistructured interviews and transcribed, coded, and analyzed them by using a thematic analytic framework with inductive and deductive approaches to examine student engagement processes.

Results

Community colleges represented campuses with (n = 6) and without (n = 6) tobacco-free policy and varied by geography (urban vs rural) and student population size. Three main themes emerged: 1) no "wrong door" for students to engage in tobacco control work, 2) a myriad of ways for students to be involved in policy adoption, and 3) benefits of student engagement.

Conclusion

We found that students are doers, allies, and champions in adoption of 100% campus tobacco-free policy. Colleges should leverage their campuses' most important assets — students — to be agents of change and to involve them in the full spectrum of interventions and advocacy.

Introduction

In 2021, young US adults aged 18 to 25 years had the highest smoking and vaping rate (14.1% or 4.7 million people) (1). Given the number of young adults attending college, a tobacco-free campus is one strategy to reduce tobacco use through student engagement (2). California Community Colleges (CCCs), the nation's largest higher education system, passed a 2018 resolution supporting the adoption and implementation of 100% tobacco-free policies (TFPs). Because the resolution is not binding, only 66% of CCCs are completely tobacco-free as of 2023 (3).

As more young adults pursue higher education (4), colleges are an opportune environment for tobacco prevention and cessation efforts. However, much of the research has focused on 4-year colleges, leaving community colleges an understudied population (5–8), which is surprising given that community college students make up more than two-fifths (42%) of all US undergraduates (9). Smoking prevalence, particularly daily smoking, is higher among community college students compared with their 4-year counterparts, and community college students are less likely to quit (10–12). Similarly, student engagement in community colleges differs from that in 4-year universities due to several factors. Community colleges tend to enroll a more diverse student body than 4-year universities, with higher proportions of low-income and first-generation college students (5). Additionally, community colleges often have fewer support services than 4-year universities (13), and the transitional nature of a community college along with a shared governance structure make TFP-related student engagement more complicated.

For more than 3 decades, student engagement has been recognized as a strategic practice in tobacco policy efforts (14). Student involvement can advance comprehensive tobacco control efforts through social norm change, particularly with counter-marketing efforts. Student engagement can yield high economic returns at low cost. The American College Health Association's (ACHA) Position Statement on Tobacco on College and University Campuses recommends the development of a tobacco task force with student involvement (15). The literature on college students' involvement in tobacco control efforts is limited. After passing a TFP, one campus found that student ambassadors improved compliance and reduced cigarette butts at campus hotspots (16). Given the dearth of research on student involvement in campus policy efforts, we conducted a qualitative study to examine the importance of student engagement in advancing 100% TFPs in community colleges and identify strategies for campuses to involve students in such efforts.

Methods

In this phenomenological study, 12 community colleges were purposively selected on the basis of criteria from our parent study that focused on facilitators and barriers to college TFP adoption. Selection criteria included geographic location and policy status and was informed by prior study results (17,18). Up to 3 key informants at each community college were recruited on the basis of their knowledge of or direct experience with the TFP adoption process and included students, staff, faculty, college leaders, or people employed with a tobacco-related community-based organization or public health department. Key informants were recruited through our study advisory board (including the California Youth Advocacy Network and the Health Services Association California Community Colleges), websites, and referrals from key informants. Recruitment was done via email and telephone. A total of 33 key informants participated.

A semistructured interview guide was developed using Ickes and colleagues' Campus Assessment of Readiness to End Smoking (19) (including resources, leadership, knowledge, campus climate, political climate, and existing tobacco control policies) and Frohlich and Abel's Institutional Study of Inequalities in Smoking (ISIS) framework (20) (including individual efforts and collective networks). Questions included experience working at the community college or in the tobacco control field, knowledge or insights on the policy adoption process, and key players, including students. Virtual interviews were conducted from January 2021 through January 2022. All key informants provided informed consent and permission to record the interview. The Public Health Institute's Human Subjects Review Committee provided institutional board review approval (study exemption no. I18–015a).

We followed Braun and Clark's reflexive thematic analytic framework, in which we acknowledged our positionality that reflects our own experiences (as students, a college administrator, and an external community partner) and our role as researchers in the interpretations of the participants' experiences (21,22). Based on Ickes and colleagues' campus readiness assessment and ISIS framework (19,20), a codebook was developed deductively (eg, campus leadership, student engagement) and, after review of the first 6 interviews as a group, inductively as new concepts emerged. The coding process began as a group with the first 3 transcripts to ensure consistency with interpretation of codes. Subsequent transcripts involved 2 coding teams (2 community college–level research assistants with support from S.L.T. and 1 graduate-level research assistant with support from C.K.L.) who independently applied codes again for the first 3 transcripts. When coding discrepancies occurred, the team discussed the issues, came to a consensus on code definition, and documented the resolution in the codebook, which was then applied to the remaining transcripts to ensure consistency. The coding teams independently coded the remaining interviews. Weekly coding sessions were conducted, and questions or conflicts were discussed and resolved. Dedoose software was used for coding (23). Excerpts under the "student" code were extracted for this study and entered into Microsoft Excel to identify patterns (Microsoft Corporation). After first review of the 132 excerpts, 10 potential themes emerged.

After the second review, we prioritized 3 themes based on the study goals to highlight unique aspects of the community college experience and inform student engagement in policy adoption. Through group discussion, exemplar quotes were selected to best characterize each theme.

Results

The selected community colleges differed by rural and urban geography and student population size. Key informants provided unique perspectives of community college students, given their relationship as students themselves or the fact that they worked closely with students through campus services or policy efforts (Table 1). Eight colleges actively involved students in the policy adoption efforts, and among them, 6 colleges or community organizations paid students via stipend or employment. Three key themes and corresponding exemplar quotes are presented (Table 2).

Theme 1: No “wrong door” for student engagement in tobacco efforts

The first theme emphasized that there is no “wrong door” for community college students to get involved in TFP work, with many opportunities for students to participate in committees advocating for TFP. Key informants reported that most students got involved formally through campus organizations such as student government (eg, Associated Students, student senate), student clubs, and health care–related majors. For example, one informant considered recruiting students mainly from health-related majors (Table 2, quote no. 1). Key informants expressed that many students were supportive of the efforts, and students viewed tobacco use as having dangerous health consequences (quote no. 2). Additionally, students can support the efforts regardless of their academic or athletic backgrounds (quote no. 3).

Students who served as campus leaders, student senate members, student health advisory committee members, or peer health educators played a crucial role in student engagement in tobacco-free efforts in CCCs, as they are respected by faculty and other leaders on campus (quote no. 4). Informants felt that it is important to educate students and staff to bring awareness to why a TFP is essential and beneficial (quote no. 5).

Key informants reported that hiring paid interns is an excellent way of getting students involved in TFP efforts and that colleges with paid and trained interns yielded better commitment and quality of work. According to one key informant from a community-based organization, the most helpful way to push the policy forward is to use students’ voices, whether in education or advocacy, and the best way to achieve that is through paid student internships (quote no. 6). A college administrator also expressed that student interns enhanced both themselves and the policy work (quote no. 7).

Theme 2: Myriad levels of student engagement in tobacco-policy work

The second theme describes the concrete tasks in which the students partake in TFP efforts. These efforts are categorized into information gathering, education and awareness, advocacy, and activism. Data collection, observational studies, surveys, and focus groups are examples of information-gathering activities. Health fairs, presentations, and tabling are examples of activities that promote education and awareness. Examples of advocacy activities for TFPs included generating peer support, being actively involved in meetings, creating videos, testifying at stakeholder or college board meetings, and participating in the student health advisory committee. Activism in TFPs can be participation in rallies, garnering letters of support from student clubs, picking up cigarette butts, and performing park clean-ups. As one key informant mentioned, involving students in TFPs is vital (quote no. 8). Similarly, by partaking in different activities, students can build support from other decision-making bodies.

The range of student engagement in tobacco control policy work also allows students to bring their own creativity to these efforts, such as with artwork or videos that use different mediums to highlight policy efforts (quote nos. 9 and 10). Key informants highlighted that students could either lead tobacco-control efforts or take a supporting role. One key informant described how students took ownership (quote no. 11). However, according to another key informant, efforts on their campus involved students in a less active, but still important, role (quote no. 12). Once students are in the space of tobacco control policy work, they are likely to become advocates for broader tobacco control efforts (quote no. 13). Finally, one key informant described the benefits of using the Truth Initiative grant funding to hire 1 to 2 students (quote no. 14). For community college students, compensation for participation was important.

Theme 3: Benefits of student engagement

The third theme describes the benefits of student engagement and the influence of students on the policy journey. A student services coordinator at one college best exemplified this theme (quote no. 15) by emphasizing the value of putting students in leadership positions. Three subthemes emerged on further analysis: 1) student influence on college decision-making communities or leaders, 2) student impact on policy, and 3) student skill-building and education.

Students influenced multiple groups, the first of which was faculty and staff, as they care about what students want on campus (quote no. 16). Moreover, students also influenced the board of trustees, a key community college governing body, to approve a TFP by providing evidence of student support on campus (quote no. 17). Given the shared governance of the CCC system, decision makers valued the support of students. Lastly, when a group of students is involved, they often attract other students to join advocacy efforts. For example, one college that has a strong collegiate athletics program worked with its student body president to bring the entire sports team to their tobacco-free campus events.

Second, students affect policy by bringing unique perspectives, roles, representations, and life experiences. One external community partner described just how extensive this impact was: what started with a paid internship ultimately led to the passing of a student government resolution (quote no. 18). The impact was especially relevant for campuses that heavily involved student leaders, such as the student body president and student trustee (quote no. 19). Multiple key informants acknowledged that students valued social justice and equity as part of the policy efforts, especially more so than groups that were more concerned about individual freedom (quote no. 20). As another unique contribution, several key informants described narratives of students who smoked but were still supportive of a TFP and how they played a crucial role in policy messaging (quote no. 21). Similarly, a student with asthma brought another powerful narrative at council meetings and on campus where they spoke about how smoke irritated their lungs. Finally, students themselves benefited greatly from being involved in these tobacco control opportunities (quote no. 22). In addition to gaining experience, they also learned about the college policy process and gained a passion for tobacco control work (quote no. 23).

Discussion

Establishing 100% tobacco-free community colleges is an effective strategy to reduce tobacco use (24,25). Given that the demographic profile of community college students tends to be young adults from communities of lower socioeconomic status and racial and ethnic minority families, a TFP could address tobacco-related health disparities (26). As of 2023, only 66% of California community colleges are 100% tobacco-free; therefore, it is a high priority for the remaining community colleges to adopt a TFP (3). In addition, given CCC's shared governance structure in which students have a voice along with faculty and staff in college- and district-wide decision-making processes, student engagement is a key ingredient for policy. However, research on student engagement in college tobacco control policy is limited. Studies that have examined student engagement were often conducted in already 100% tobacco-free campuses and focused on the role of student engagement to improve TFP compliance (2,27,28). Findings showed that students report mixed feelings regarding their role and level of authority and often feel uncomfortable approaching others who are smoking on campus (2,27,28). The policy violators also expressed feeling uncomfortable being approached by student ambassadors; however, most of them reported the ambassadors approached them with kindness and they had a positive experience interacting with them (2). Nevertheless, to our knowledge, this is the first study that explores the roles of student involvement in TFP adoption efforts on community college campuses using a sample of 12 community colleges in California. Findings on how campuses leveraged student voices and involvement can serve as a roadmap for other colleges who are advocating for a TFP.

The first theme highlighted that many ways exist for students to get involved in TFP efforts, advocate for policy change, and ultimately achieve a tobacco-free campus. Students have some of the most effective voices to advocate for what they believe is right (29). Students do not need to come from any specific background to get involved in this work, as long as they are passionate and interested in campus involvement. They can become ambassadors or student interns who deliver presentations at classrooms or board meetings. Students can even informally support policy efforts by completing surveys, participating in tobacco-free events such as the Great American Smoke Out, and voicing their opinions about passing a TFP on their college campus. Community colleges could use a range of methods and channels for engaging students.

Students majoring in health-related disciplines are often the most deeply involved in tobacco-free efforts because they are the ones who have an interest in public health. Most students who lead tobacco control efforts on their campuses tend to major in health-related fields and have a passion to serve and improve community health (2,27,28). Administrators can reach out to students who are passionate about social justice and public health issues who can become advocates for TFP efforts. They could build advocacy skills, provide training, and create a space for students to lead these policy efforts. If successful in educating young adults about the negative impact of tobacco smoke, students from other fields or majors may be willing to participate in TFP efforts.

Lastly, community colleges should consider dedicated funds for student engagement positions, such as through internal campus funding or external grants like the Truth Initiative (https://truthinitiative.org/) that supports campus tobacco policy efforts. Having paid student interns is an effective way to engage students because they commit their time and energy to the work more than they would with a volunteer position. As Hunt and Scott noted, paid internships require interns to be more responsible and therefore provide much higher quality work (30). The large population of low-income students at community colleges (5) may be more likely to look for paid positions, and paid student internships would offer them the opportunity to earn money while building their work experience.

Theme 2 highlighted the myriad ways in which students can be actively involved once they enter the space of TFP work. They bring their creativity into the space, and as agents of change (31), students understand social norms around tobacco use among their peers in ways that are different from campus administrators and other professionals. Providing such an environment also makes participation more appealing and encourages students to develop passion and investment in tobacco policy work. For example, through the creation of artwork, students visually expressed themselves and demonstrated how a tobacco-free campus matters to them.

Additionally, college administrators and staff need to recognize that having students involved in TFPs creates an environment that is open to change since students can be champions of change. This aligns with the Centers for Disease Control and Prevention's 2010 Best Practices User Guide, which stated, "Youth enhance state and local tobacco control efforts by challenging conventional thinking, advocating for policies, and changing the social norms around tobacco use" (14). However, college administrators and staff should keep in mind that the benefits of student engagement should outweigh the risks in tobacco control efforts, as one TFP compliance study found that students may not be the best to deliver the intervention (27).

This theme also emphasized that students' level of involvement in TFPs mattered. This pattern highlighted the value of student engagement as students took ownership of TFP efforts on their campuses. This is an essential lesson that community colleges that are not yet tobacco-free can incorporate for more successful efforts. Lastly, involving students in policies at their school creates an avenue for them to get more involved in local and statewide tobacco-free policies, an excellent opportunity for training students on policy advocacy and tobacco control experience for the future.

The third theme captured the benefits of student engagement, as students influence other stakeholders, including faculty, staff, and the board of trustees. Students themselves also gain knowledge, experience, and passion for advocacy. The investment of students in showing support for policy results in faculty, staff, and decision makers being interested in moving policy forward because students really are the "consumers" of community colleges, a mindset that has had a positive impact on universities (32). Thus, engaging multiple student groups results in the policy gaining more traction. Each student who is engaged also brings in more students who can continue to expand the circle of student supporters as exemplified by the sports teams supporting advocacy in one community college.

The student viewpoint often focuses on issues that students are facing first-hand and are passionate about. This perspective places students in the forefront in gathering the student body's support while representing the student voice. If students are not engaged, ensuring the student perspective can be easily forgotten. Because students are also most affected by policy changes, the personal stories they share can carry weight throughout the campus community, so providing a platform for them to speak is critical.

Being engaged in TFP advocacy does not send students home empty-handed, but rather offers them distinct hands-on opportunities as they grow into more informed and empowered individuals. This type of experiential learning is what the Association of American Colleges and Universities calls "high impact practices" that provide significant educational benefits for students who participate in them (33). In fact, emphasizing student advocacy engagement through movements like this is a major part of most colleges' mission statements. An urban Bay Area campus aims to "inspire participatory global citizenship grounded in critical thinking and an engaged, forward-thinking student body." Students can best grow in participatory citizenship when involved in advocacy work. Similarly, a larger Southern California urban campus's goal was to "create conditions for empowerment, critical thinking, and informed civic engagement" for their students. Adopting a 100% TFP on campus is a prime example to foster this goal and to empower students and showcases how central to the college experience student engagement can be.

Strengths and limitations

Although a multi-campus qualitative study provides a rich, nuanced lens to understanding student engagement efforts, our study has limitations. The semistructured interviews allowed respondents to discuss students' involvement within the broader context of other barriers and facilitators of establishing campus TFPs. Among the 33 key informant interviews, 3 were students, which represented a small proportion. Identifying more students to participate as key informants may have shown a more in-depth perspective on their involvement, bringing in a greater volume of primary sources. This study team included 3 currently enrolled undergraduate students, all of whom were recent community college students themselves who were deeply involved in data collection, analysis, and writing of this manuscript; their engagement exemplifies yet another entry point to integrate student voices. Also, 4 campuses (2 with TFPs and 2 without) did not have student involvement in TFP efforts; nevertheless, we included them in this study, as key informants expressed difficulties in engaging community college students given their limited time on campus. Because the study was done with community college campuses and because of the small sample size (ie, 12 colleges), findings may not be generalizable to 4-year institutions or schools outside of California.

Implications

Students are important partners in the journey to TFP adoption. As Jazwa et al noted, students are the most commonly cited contributors to advancing policy change (34). This is no coincidence. ACHA standards recommend a community-based approach to facilitate change; students, one of the most impactful groups in the community, must be engaged. Moreover, students can be involved and empowered in multiple ways through many doors and a range of activities. Students can be agents of change in leading community college policy efforts. Whether through internship programs, student government, or survey responses, the student voice has power that can advance community college TFPs. Considering the limited amount of research on student engagement in TFP adoption, this article highlights the key role of students in moving campuses toward comprehensive policies in the CCC system.

Conclusions

Institutions of higher learning should leverage their campuses' most important assets — students — and involve them in the full spectrum of interventions and advocacy. The themes described in this article emphasized not only multiple entry points for students' involvement but that there is no "wrong door" to engage students. We recommend creating opportunities for students in a purposeful, intentional manner while being careful not to make them into tokens. Creating leadership opportunities for students can help to advance tobacco control opportunities and reduce tobacco-related disparities, especially in community colleges.

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Tables

Table 1. Characteristics of Colleges (N = 12) and Key Informants (N = 33) in Study Sample, Survey on Tobacco-Free Policies of California Community Colleges, 2021–2022

College no.	Region, geography	Has 100% tobacco-free policy, year policy adopted	Student population size, 2019	Campus lead in policy adoption	Has external campus partner	Student involvement in policy efforts	Key informant no., title
CS1	Northern California, rural	Yes, 2019	9,315	Student health center and student services	No	Yes	17, Student health center director 19, Student health center director 20, Student services director
CS2	Northern California, rural	No	10,942	Campus smoke-free task force	CBO	No	14, CBO project director 16, CBO health educator 33, Student health center director
CS3	Bay Area, urban	Yes, 2018	24,344	Campus–community smoke-free task force	CBO	No	2, Student health center director 3, CBO project director 4, Student health services staff
CS4	Bay Area, suburb	Yes, 2021[a]	8,537	Faculty–community organization	CBO	Yes, paid	5, College faculty 6, Student health center nurse 7, Student 13, CBO project director/staff
CS5	Central California, urban	Yes, 2016	11,840	Campus–community task force	County public health department	Yes	25, Student health center nurse 26, College vice president 34, County tobacco control specialist
CS6	Central California, urban	No	13,856	Student health center	No	No	24, Student health center director
CS7	Los Angeles, urban	Yes, 2013	29,057	Student health center and student services	No	No	29, College institutional effectiveness director 35, College vice president
CS8	Los Angeles, urban	No	19,997	Student health center	CBO	Yes, paid	11, Student health center nurse 12, Student health center director 18, CBO project director
CS9	Southern California, urban	No	16,405	Student health center	County public health department	Yes, paid	23, Student health center director 37, County tobacco control program supervisor
CS10	Southern California, urban	No	14,228	Student group–community organization	CBO	Yes, paid	27, CBO senior tobacco control manager 32, CBO community engagement manager 36, Student

Abbreviation: CBO, community-based organization.

[a] At the start of the study CS4 did not have a tobacco-free policy but adopted the policy during this study.

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Table 1. Characteristics of Colleges (N = 12) and Key Informants (N = 33) in Study Sample, Survey on Tobacco-Free Policies of California Community Colleges, 2021–2022

College no.	Region, geography	Has 100% tobacco-free policy, year policy adopted	Student population size, 2019	Campus lead in policy adoption	Has external campus partner	Student involvement in policy efforts	Key informant no., title
CS11	Northern California, rural	Yes, 2021	1,862	Student services	CBO	Yes, paid	15, Student/CBO college coordinator 21, CBO project director 31, College vice president
CS12	Central California, rural	No	2,873	Student health center	CBO	Yes, paid	9, CBO project director 10, Student health center director 22, College director of research

Abbreviation: CBO, community-based organization.

[a] At the start of the study CS4 did not have a tobacco-free policy but adopted the policy during this study.

Table 2. List of Exemplar Quotes From Key Themes, Survey on Tobacco-Free Policies of California Community Colleges, 2021–2022

Quote no.	Quote code	Theme	Quote
1	CS11, no. 15 student and external partner organization	Theme 1: no wrong door for student engagement in tobacco efforts	“Our premed and nursing clubs would have been probably the ones off the top of our head.”
2	CS12, no. 9 external partner organization		“When they started bringing that topic [campus smoke-/tobacco-free policy] to the associated students, the feeling among the students was that they were generally supportive. There was no student who was like ‘No, we don’t want this to happen,’ they were all like ‘Yeah, that makes sense. We should do this.’”
3	CS11, no. 15 student and external partner organization		“We found that students do not have to come from a specific background to join tobacco policy efforts. They could be in any academic field, even athletics since ‘the teams are big so like if you get one team involved, you can easily get 10 to 30 people out of it. . . . With . . . Earth Day . . . we have at least 15 basketball players choose themselves. . . . If you get one person on the team excited about it, then we’re likely [to have] . . . a whole bunch of fans [too].’”
4	CS2, no. 16 external partner organization		“We can have those points of contact where we say like, ‘Hey, you were on student senate, we heard that you were interested in this, come join our advisory committee,’ and then we’re able to build up those ranks of people on campus who do have the passion, interests, and also have been in a leadership role that like faculty leadership would respond to on campus.”
5	CS7, no. 35 college administrator		“The peer health educators . . . were doing a campaign associated with what [e-cigarette] and vaping could do, like mouth cancer. . . . They were trying to bring some awareness about that and how e-cig smoke actually can do worse damage to the lung.”
6	CS12, no. 9 external partner organization		“[A strategy that has been working for us is] paid student internships. I think bringing that social justice and environmental justice to [the] lens of student interns so that they get kind of passionate about [tobacco-free policy] has been helpful.”
7	CS12, no. 22 college administrator		“[An external partner] had employed two of our students as interns, and my motivation was to provide an educational opportunity for those students. . . . They were really driving.”
8	CS2, no. 16 external partner organization	Theme 2: myriad levels of student engagement in tobacco-policy work	“It goes back to that ownership of what’s happening on campus, and then it’s working with those students to do different evaluations, or things on campus, continuing to raise awareness, setting up meetings, usually with the associated students or the student senate, whatever the structure is on campus.”
9	CS9, no. 37 external partner organization		“Students created their own artwork depicting why they thought that the campuses should go smoke-free. . . . Student artwork made it onto a bus shelter, ads, and billboards and other artwork . . . was placed on and around the school campuses.”
10	CS9, no. 37 external partner organization		“[The students] created this really wonderful kind video that shows testimonials from different students and faculty sharing why they wanna see their campuses go smoke-free.”
11	CS5, no. 26 college administrator		“[If students] wanted to get in front of the board and say why this shouldn’t happen that could have made it a much more difficult process to adopt the policy, but you know, thankfully for us, we had a student body that again understood that this was the right thing and they were supportive and helped us implement as opposed to trying to be obstructionist at all.”
12	CS9, no. 37 external partner organization-LLA		“[We have been] gauging the students as necessary, but then you have to be able to tell them, Ok, these are the steps that we need to take. So yes, gather the data, gather the evidence, show the support from the students.”
13	CS10, no. 32 external partner organization		“Some of the students from the school actually came out and spoke in city council, and so they’ve tried to also make sure that the students are also involved in local [city] policy, not just at their school. And they really enjoyed it.”
14	CS12, no. 9 external partner organization		“[Students] did really advocate for the policy. They did this survey; I know they did presentations to decision-making groups. I think they went to the faculty senate and the staff; they might have talked to the president and the students, and they were trying to gain support from all these decision-making bodies.”
15	CS1, no. 20 college administrator	Theme 3: benefits of student engagement	“I very much looked to students just for their experience, and perspective. . . . And so I think [it’s] so important . . . to put students in . . . a position of power. You know kind of let them take a lead, and not only does that obviously give them great experience that they’ll take later in life, but I feel like I learn so much from students.”
16	CS12, no. 10 student health center		“I know the main players that are looked to for campus policies are students. So if students initially say that’s what they want, they can rally around the committee structure that moves it up into policy.”

Abbreviation: LLA, local lead agency.

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Table 2. List of Exemplar Quotes From Key Themes, Survey on Tobacco-Free Policies of California Community Colleges, 2021–2022

Quote no.	Quote code	Theme	Quote
17	CS10, no. 36 student		"It has to be a community effort because if I could get 75% or 52% of the students to say that this is important and this is something that they value in their college community, or even probably 35% or you know what whatever the statistic could be, then it would become important to the board and it would become important to the people that oversee the bigger policies."
18	CS12, no. 9 external partner organization		"Because if we didn't have Jon [student intern], the students wouldn't have adopted this resolution [in student government] I don't think. And Jon wouldn't have known that this is such an important issue unless we advertised a paid student internship."
19	CS5, no. 26 college administrator		"You know we did have students at everywhere along the way weighing in, and I think they did a good job representing what the students wanted the campus to look like."
20	CS12, no. 10 student health center		"The students really picked up that piece saying that you're not free you know, it's not a freedom issue to make other people sick . . . and I think it was best to come from the students."
21	CS1, no. 20 college administrator		"So, while there was you know obviously a lot of people feeling alienated and upset about the policy, there were also those students who could see the value in it, and I felt like he was such an asset to trying to reach out to those students and help them understand like we really just want what's best for you. We're not trying to alienate you from this campus, this campus is just as much yours as the rest of ours."
22	CS10, no. 27 external partner organization		"What really got them [the students] involved . . . was just all the policy work that we were doing and the opportunities for them to be part of what [the American Cancer Society] could offer, [whether] it will be state work or going to DC . . . as part of our national lobby day effort. Or to get involved with the larger effort because a lot of them were looking to transfer to a 4-year university so that appealed to them."
23	CS12, no. 9 external partner organization		"Yeah, he [student intern] kind of cared about tobacco and smoking, but it's probably not his top issue that he cares about. But bringing him into this and then having him host and attend different webinars and he's just like really gotten into it and really like this social justice part of it, inequity and stuff. And so now he can take that passion with him."

Abbreviation: LLA, local lead agency.

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