WOMEN'S HEALTH

Women's Health
Volume 19: 1–13

DOI: 10.1177/17455057221147380
journals.sagepub.com/home/whe
SAGE

Using medical expenditure panel survey data to explore the relationship between patient-centered medical homes and racial disparities in severe maternal morbidity outcomes

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Abstract

Background: There are persistent racial/ethnic disparities in the occurrence of severe maternal morbidity. Patient-centered medical home care has the potential to address disparities in maternal outcomes.

Objectives: To examine (1) the association between receiving patient-centered medical home care and severe maternal morbidity outcomes and (2) the interaction of race/ethnicity on patient-centered medical home status and severe maternal morbidity.

Design/Methods: Using 2007 to 2016 data from the Medical Expenditures Panel Survey, we conducted a cross-sectional study to estimate the association between receipt of care from a patient-centered medical home and the occurrence of severe maternal morbidity, and racial-specific (White, Black, Asian, Other) relative risks of severe maternal morbidity. Our study used race as a proxy measure for exposure racism. We identified mothers (⩾15 years) who gave birth during the study period. We identified patient-centered medical home qualities using 11 Medical Expenditures Panel Survey questions and severe maternal morbidities using medical claims, and calculated generalized estimating equation models to estimate odds ratios of severe maternal morbidity and 95% confidence intervals.

Results: Among all mothers who gave birth ($N=2801$; representing 5,362,782 US lives), only 25% received some exposure patient-centered medical home care. Two percent experienced severe maternal morbidity, and this did not differ statistically ($p=0.11$) by patient-centered medical home status. However, our findings suggest a 85% decrease in the risk of severe maternal morbidity among mothers who were defined as always attending a patient-centered medical home (odds ratios: 0.15; 95% confidence interval:0.01–1.87; $p=0.14$) and no difference in the risk of severe maternal morbidity among mothers who were defined as sometimes attending a patient-centered medical home (odds ratios: 1.00; 95% confidence interval:0.16–6.42; $p=1.00$). There was no overall interaction effect in the model between race and patient-centered medical home groups ($p=0.82$), or ethnicity and patient-centered medical home groups ($p=0.62$) on the severe maternal morbidity outcome.

Conclusion: While the rate of severe maternal morbidity was similar to US rates, few mothers received care from a patient-centered medical home which may be due to underreporting. Future research should further investigate the potential for patient-centered medical home-based care to reduce odds of severe maternal morbidity across racial/ethnic groups.

Keywords

maternal health disparities, maternal health outcomes, patient-centered medical homes, severe maternal morbidity

Date received: 20 April 2022; revised: 18 November 2022; accepted: 8 December 2022

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Introduction

Background

An estimated 60,000 people each year in the United States are affected by a severe maternal morbidity (SMM).[1] SMM is a maternal safety event that occurs during pregnancy or up to 1 year in the postpartum period and can result in serious complications (e.g. hysterectomy, severe sepsis, cardiac or respiratory arrest, etc.).[2] A maternal death is the death of a woman while pregnant or within 42 days of the end of pregnancy, and in 2020, 861 people died from maternal causes in the United States, which was an increase of 14% in 1 year,[3] and a large racial disparity exists between Black and White patients. The rates of pregnancy-related death have been rising for years, but the COVID-19 pandemic exacerbated this racial disparity.[4] The United States has a significantly higher rate of pregnancy-related death compared to other industrialized countries, and for every pregnancy-related death, there are approximately 70 people with an SMM.[5] Pre-existing comorbidities and prenatally acquired comorbidities put people at higher risk for SMM, subsequent pregnancy-related death, and cardiovascular disease later in life.[6,7] Of all US pregnant people, 44.1% had at least one obstetric comorbidity[8] based on the Obstetric Comorbidity Score, a weighted algorithm measuring pre-existing comorbidities, pregnancy-related conditions, and other factors.[9] Measurement of SMM is important for identifying and investigating opportunities to prevent SMM and maternal death at the population level.[2]

There is a persistent racial disparity in the occurrence of SMM between Black and White people. In a population-based analysis from 2008 to 2010 of childbirth hospitalizations in seven states, Black people had 2.1 times higher rates of SMM compared to White people.[10] From 2011 to 2013 using New York City discharge data, the rate for SMM for Black to White mothers was 4.2% to 1.5%, and after adjustment for confounders, the odds ratio for SMM was 2.02 for Black mothers.[11] In a study investigating neighborhood racial and economic polarization and SMM in New York City from 2012 to 2014, people residing in zip codes with the highest concentration of poor Black people in relation to wealthy White people, there was a 2.4 risk difference for SMM.[12] Exposures to the harms of systemic racism have historically led to poor health outcomes for racial/ethnic minoritized groups.[13,14] It is critical that researchers identify interventions and healthcare practices that can eliminate maternal health inequalities. The authors emphasize that race is a social construct, rather than a biological one, and differences in exposures to systematic oppression, policies, and structures lead to differences in health outcomes by race.[14]

A patient-centered medical home (PCMH), as defined by the Agency for Healthcare Quality and Research (AHRQ), is a primary care approach that focuses on healthcare needs that are patient-centered, comprehensive, coordinated, accessible, and dedicated to quality and safety.[15] Providers in a PCMH practice shared decision-making with their patients, and this can result in reduced fragmentation of care. Research supports that PCMH improve patient experiences and healthcare quality, including increased use of preventive services and disease management.[16] Several studies have examined how PCMHs address health outcomes and alleviate health disparities, but results are mixed.[17–19] In a retrospective cohort analysis from 2010 examining disparities in income and educational groups, there was no evidence that PCMHs alleviated disparities.[18] In a retrospective cohort analysis examining a Latino population in 2005, care access increased for those in a PCMH.[20] In a retrospective observational study of veterans, clinical outcomes such as hypertension and diabetes control were worse for Black and Hispanic patients after PCMH implementation as compared to pre-implementation.[21]

Care delivered guided by PCMH principles for perinatal care addresses the social determinants of health that arise during pregnancy.[22] PCMH care has the potential to improve access to management of pre-existing and maternal comorbidities. In 2011 the North Carolina Division of Public Health implemented the Pregnancy Medical Home program for mothers on Medicaid with the aim to reduce the rates of primary cesarean sections and babies born at low-birthweight, and data show promising improved outcomes.[5]

Several investigators have used large datasets, such as the Medical Expenditures Panel Survey (MEPS), to examine maternal outcomes such as maternal mental health, chronic illness, gestational diabetes, and disability.[23–29] Based on examination of the extant literature, no studies have examined how care received through the PCMH affects maternal outcomes such as SMMs or whether PCMH care reduces racial differences in maternal outcomes. There is a need to investigate the association among PCMH care, SMM risk, and racial disparities in SMM in the United States using population-based data.

The present study advances knowledge about the relationship between PCMH care delivery and maternal outcomes and is one of the few that have examined this relationship. The objectives of this study were (1) to examine the association between PCMH and SMM outcomes and (2) examine the association between PCMH use among racial/ethnic groups on the prevalence of SMM among people who gave birth. We hypothesized that people receiving care consistent with PCMH principles would have a lower risk of SMM. We further hypothesized that there would be an interaction between respondent race and PCMH status with SMM as an outcome.

Methods

Study design and data source

The MEPS is a nationally representative survey of access to care, women and children's health, chronic conditions, health insurance, disabilities, health disparities, and

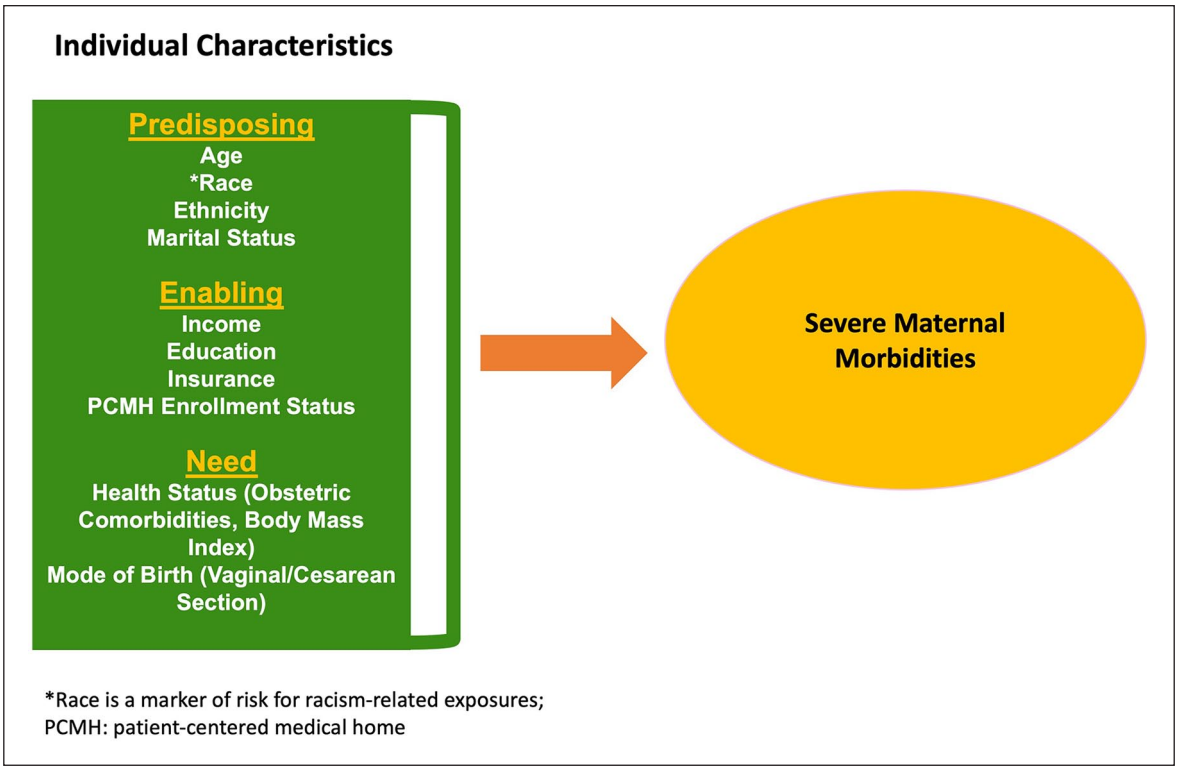

Figure 1. Andersen–Howell integrated model of pathways to reduce disparities in severe maternal morbidity model.

prescription drug use for noninstitutional US households. The MEPS is derived from respondents who participate in the National Health Interview Survey.[30] We conducted a cross-sectional study using the MEPS for the years 2007 to 2016. This study used the full-year consolidated files which include the self-reported diagnoses of disease conditions linked to International Classification of Diseases (ICD) 9th and 10th Edition codes medical condition files reported by the providers. Examples of claims include inpatient, outpatient, home health, office-based, emergency room encounters. Person-weight and variance estimation stratum are assigned to each respondent based on population characteristics and survey non-response. Participants partake in five overlapping rounds of interviews over a 2-calendar year period, which allows the MEPS to capture a broad range of pregnancy conditions. The survey oversamples racial and ethnic minority populations (e.g. Black and Hispanic), which allows for higher statistical power in these populations in health disparities research.[20] Survey questions in the MEPS have demonstrated good overall response validity[31] and modest to strong predictive validity of primary care indicators.[32]

The study meets the Not Human Subject criteria set forth by the Code of Federal Regulations (45 CFR 46) of (a) the specimens and/or private information/data were not collected specifically for the currently proposed research project through an interaction/intervention with living individuals; and (b) the investigator(s) including collaborators on the proposed research cannot readily ascertain the identity of the individual(s) to whom the coded private information or specimens pertain.

Study sample

MEPS respondents who had a birth event were identified and will be referred to as mothers for the duration of this manuscript. We included mothers aged 15 years and older from panels 12 to 20 for a total of $N=3305$ mothers with 56,331 claims. Mothers in the MEPS were selected based on having a pregnancy-related event via the medical conditions inpatient claims file. Mothers were excluded based on death of the mother, if they did not participate in all five rounds of the survey, and if they had responses that did not allow us to attribute them to a primary care model. Duplicate claims for mothers were removed. For the descriptive analysis, the study sample included $n=2801$ mothers. In our final statistical model, we also excluded mothers with missing insurance status data bringing the study sample to $n=1549$.

Study variables

The conceptual framework for this study was the adapted Andersen–Howell Integrated Model of Pathways to Reduce Disparities in SMM (see Figure 1).[33,34] Variables

Table 1. Centers for disease control and prevention severe maternal morbidity indicators.

Severe maternal morbidity indicator
Acute myocardial infarction
Aneurysm
Acute renal failure
Adult respiratory distress syndrome
Amniotic fluid embolism
Cardiac arrest/ventricular fibrillation
Conversion of cardiac rhythm
Disseminated intravascular coagulation
Eclampsia
Heart failure/arrest during surgery or procedure
Puerperal cerebrovascular disorders
Pulmonary edema/acute heart failure
Severe anesthesia complications
Sepsis
Shock
Sickle cell disease with crisis
Air and thrombotic embolism
Blood products transfusion
Hysterectomy
Temporary tracheostomy
Ventilation

Table 2. Patient-centered medical home categorization.

PCMH characteristic	MEPS item (response choice)
Comprehensive care	• Provider asks about other treatments? (yes/no). • Go to usual source of care for new health problems? (yes/no). • Go to usual source of care for preventive healthcare? (yes/no). • Go to usual source of care for referrals? (yes/no). • Go to usual source of care for ongoing health problems? (Yes/No).
Patient-centered care	• Provider shows respect for treatments? (never, sometimes, usually, always). • Provider explains options to person? (yes/no). • Provider asks person to help decide? (never, sometimes, usually, always).
Accessibility	• Unable to get necessary medical care? (yes/no). • Usual source of care has office hours nights/weekends? (yes/no). • Provider Speaks person's language? (yes/no).

PCMH: patient-centered medical home; MEPS: Medical Expenditures Panel Survey.

were chosen based on known empirical relationships with SMM disparities and available measures in the MEPS, as seen in previous studies.[9,11,35]

Our outcome variable was an indicator for SMM which were identified based on the publicly available ICD codes and clinical classification codes (CCC) in the MEPS. Clinical classification codes are condensed ICD codes in the MEPS which are organized into clinically meaningful categories. We created indicators for SMM using both ICD and CCC to increase our accuracy of identifying a diagnosis. An SMM was defined based on the Centers for Disease Control and Prevention's (CDC) criteria to define the SMM (see Table 1).[36] We defined a SMM as occurring within one round before or after the birth due to the nature of the overlapping panel design and increase the accuracy of detecting an SMM up to 1-year post birth.

Claim. Our primary predictor was PCMH care. We used respondent answers to questions that are believed to capture care that is consistent with PCMH characteristics using previous approaches to determine the type of primary care provider for MEPS respondents.[37–40] Briefly, the approach uses 11 MEPS questions that describe PCMH principles to attribute patients to a medical home, including comprehensiveness, patient-centeredness, and enhanced access based on AHRQ criteria, as shown in Table 2. The PCMH questions are assessed in round 2 and 4 of the survey. The comprehensive care items assess thoroughness of care, the patient-centered care items assess the patient-provider relationship, and the accessibility items assess the level of ease in which the respondent can contact their provider. Mothers who had positive responses for all items in Table 2 were coded as receiving care from a PCMH. For example, yes to all yes/no items or sometimes, usually or always to the items on the Likert-type scale. In all analyses, race was used as a proxy for exposures associated with race (racism, pollution, differential care, etc).[14,41,42]

We attributed mothers into one of three primary care groups: (a) non-PCMH: mothers who did not respond "yes" to all PCMH questions in both rounds 2 and 4; (b) PCMH—sometimes: mothers who answered yes to all PCMH questions during either round 2 or round 4 (PCMH—sometimes); and (c) PCMH—always: mothers who answered yes to all of the PCMH questions in both rounds 2 and 4 (PCMH—always). We also conducted an exploratory analysis whereby the PCMH sometimes and always groups were combined and compared to the PCMH never group.

Covariates assessed in this study include the following: (1) predisposing factors: age; racism, using race as a proxy for exposure (White, Black, Asian, Other); ethnicity (Hispanic, not Hispanic); marital status (Married, not married, etc.); (2) enabling factors: income; education (less than high school, General Education Development Test (GED), high school diploma, 4-year degree, Masters or Doctorate, other); insurance (public, private, none); and (3) Need factors: health status (obstetric-related comorbidities, body mass index (BMI)); and mode of birth (vaginal, cesarean section).[33,34] Insurance type and

marital status were asked in multiple rounds of the survey, so to mitigate this issue, we analyzed the first recorded values for these variables. BMI and family income were continuous variables also measured in multiple rounds; we created a variable representing the mean value across all rounds to use in the analyses.

Obstetric-related comorbidities were identified based on the Expanded Obstetric Comorbidity System for Predicting SMM.[35] In this system using ICD codes, the authors ranked each obstetric-related comorbidity based on its contribution of risk toward an SMM. One adjustment that we made to this scale was that we did not categorize age $\geqslant 35$ and BMI $\geqslant 40$ as an obstetric-related comorbidity because we wanted to assess how each behaved as independent covariate.

Statistical analyses

We computed descriptive statistics (frequencies or means) for each of the three PCMH attribution groups. We tested for differences in population characteristics across groups using survey-adjusted chi-square tests and standard F-tests, where appropriate. We used survey-adjusted bivariate logistic regression models to test for population differences in the SMM outcome. Using a model building approach, we identified all variables from the bivariate analysis of the outcome of interest (SMM) with a significance value of $p \leqslant 0.2$. We computed a generalized estimating equation (GEE) model to estimate the odds ratio of SMM using person-specific sampling weights in the survey. The survey weights were averaged over the study period, based on recommendations from AHRQ for combining multiple years of data.[43] We computed the GEE model using the entire sample of MEPS participants during the study years and created an indicator to identify the mothers of interest to avoid underestimating the standard errors. Finally, we tested the interaction effect of race and PCMH groups on the SMM outcome.

A p-value < 0.05 indicated statistical significance for this study. Power analysis indicated that for a sample size of 2801 unique mothers, at an α level of 0.05, power of 0.8, R^2 of the other predictors at 0.2, our study would be able to detect an effect with an odds ratio of 1.5 for predicting SMM, which has a prevalence rate of 2%. All analyses were conducted with the use of STATA 16.1 software (Stata Corporation, College Station, TX).

Results

Sample characteristics

Table 3 displays the baseline characteristics for all mothers and by PCMH category. We began with 3423 births 30,855 claims and $N = 3305$ unique mothers. After applying exclusion criteria, these numbers were reduced to 2907 births, 27,387 claims, and $N = 2801$ mothers representing 5,362,782 US lives. In the final sample of our study, the majority of mothers were White (78%), followed by Black (13%), Asian (6%), and Other (3%). Approximately 23% of mothers in the final sample of our study identified as Hispanic. The mean age was 28 years ($SD = 6$). More than half of mothers were married (55%) and had a high school diploma or higher (54%). For average annual family income, most mothers reported earning >US$50,000 (51%). Sixty-five percent of mothers had public insurance, 29% had private insurance, and 6% were uninsured. An SMM was experienced by 2% of mothers representing 109,297 US lives and did not differ significantly ($p = 0.78$) by racial groups (see Table 4). Among all mothers, 76% were never in a PCMH, 18% were sometimes in a PCMH, and 7% were always in a PCMH. An obstetric-related

Table 3. Baseline characteristics and comparisons between recipients by PCMH status (unweighted *N*, weighted *N* (%), or mean ± SD) total sample = 2801.

	Overall	Not PCMH (76%)	PCMH sometimes (18%)	PCMH both rounds (7%)	*p* value
SMM					
No	2742 5,253,484 (98%)	2098 3,978,035 (98%)	474 925,490 (98.3%)	170 349,960 (99.8%)	0.11
Yes	59 109,297 (2%)	50 92,657 (2.3%)	8 15,781 (1.7%)	1 859 (0.2%)	–
Race					
White	1949 4,181,077 (78%)	1512 3,180,543 (78.1%)	328 733,992 (78.0%)	109 266,542 (76.0%)	0.96
Black	568 707,885 (13.2%)	413 523,235 (12.9%)	110 131,198 (13.9%)	45 53,452 (15.2%)	–
Asian	191 335,266 (6.3%)	150 257,263 (6.3%)	29 55,122 (5.9%)	12 22,880 (6.5%)	–
Other	93 138,554 (2.6%)	73 109,651 (2.7%)	15 20,959 (2.2%)	5 7944 (2.3%)	–

(Continued)

Table 3. (Continued)

	Overall	Not PCMH (76%)	PCMH sometimes (18%)	PCMH both rounds (7%)	*p* value
Ethnicity					
Hispanic	1045 1,215,797 (22.7%)	842 989,860 (24.3%)	162 186,625 (19.8%)	41 39,312 (11.2%)	0.00
Not Hispanic	1756 4,146,985 (77.3%)	1306 3,080,832 (75.7%)	320 754,646 (80.2%)	130 311,507 (88.8%)	–
Insurance coverage year 1					
Public	725 1,867,925 (65.2%)	536 1,381,035 (63.8%)	139 351,221 (68.1%)	50 135,669 (72.6%)	0.08
Private	647 817,450 (28.5%)	494 623,739 (28.8%)	113 145,484 (28.2%)	40 48,228 (25.8%)	–
None	162 180,436 (6.3%)	143 158,377 (7.3%)	15 19,195 (3.7%)	4 2865 (1.5%)	–
Age	28.3 (SD = 5.68)	28.1 (SD = 5.8)	28.7 (SD = 5.5)	29.4 (SD = 5.1)	0.00
Marital status					
Married	1303 2,972,235 (55.4%)	983 2,205,101 (54.2%)	232 542,228 (57.6%)	88 224,906 (64.1%)	0.24
Divorced	40 86,322 (1.6%)	29 60,703 (1.5%)	7 15,296 (1.6%)	4 10,322 (2.9%)	–
Never married	1102 1,583,488 (29.5%)	860 1,260,248 (31.0%)	180 243,574 (25.9%)	62 79,666 (22.7%)	–
Other	356 720,737 (13.4%)	276 544,640 (13.4%)	63 140,172 (14.9%)	17 34,925 (10.2%)	–
Highest degree					
No degree	418 512,127 (12.3%)	333 421,745 (13.3%)	66 68,221 (9.2%)	19 22,161 (8.0%)	0.10
GED	76 123,269 (3%)	50 90,075 (2.9%)	21 26,192 (3.5%)	5 7001 (2.5%)	–
High school	763 1,444,629 (34.6%)	603 1,120,726 (35.5%)	120 248,021 (33.6%)	40 75,883 (27.3%)	–
4-year college	296 801,482 (19.2%)	208 566,202 (17.9%)	64 157,350 (21.3%)	24 77,931 (28.0%)	–
Masters or Doctorate	162 451,045 (10.8%)	120 332,179 (10.5%)	24 71,398 (9.7%)	18 47,468 (17.0%)	–
Other	439 845,969 (20.3%)	325 629,871 (19.9%)	86 168,025 (22.7%)	28 48,063 (17.3%)	–
Family income year 1					
US$0–US$25,000	1121 1,498,515 (27.9%)	898 1,218,347 (29.9%)	176 224,726 (23.9%)	47 55,442 (15.8%)	0.01
US$25,001–US$50,000	641 1,133,496 (21.1%)	493 871,508 (21.4%)	113 202,538 (21.5%)	35 59,449 (17.0%)	–
US$50,001–US$100,000	670 1,655,354 (30.9%)	492 1,181,579 (28.0%)	126 337,613 (35.9%)	52 136,162 (38.8%)	–
US$100,001 +	369 1,075,417 (20.1%)	265 799,258 (19.6%)	67 176,393 (18.7%)	37 99,766 (28.4%)	–
BMI	27.5% (SD = 6.6)	27.4 (SD = 6.5)	27.5 (SD = 6.5)	28.8 (SD = 8.1)	0.41
OB comorbidity					
No	2445 4,632,364 (86.4%)	1892 3,549,322 (87.2%)	412 801,892 (85.2%)	141 281,150 (80.1%)	0.09
Yes	356 730,418 (13.6%)	256 521,370 (12.8%)	70 139,379 (14.8%)	30 69,669 (19.9%)	–
Mode of birth					
Vaginal	1816 3,442,994 (68.6%)	1385 2,590,521 (67.9%)	317 625,436 (70.7%)	114 227,037 (70.3%)	0.60
C-section	825 1,578,709 (31.4%)	641 1,223,689 (32.1%)	137 259,284 (29.3%)	47 95,735 (29.7%)	–

PCMH: patient-centered medical home; SMM: severe maternal morbidity; SD: standard deviation; BMI: body mass index; OB: obstetric-related; GED: General Education Development Test.
Total may not equal 100% due to rounding.

comorbidity was experienced by 14% of mothers, representing 730,418 US lives. The bivariate comparisons by PCMH status that were significant were ethnicity, age, and mean family income. Table 4 displays the bivariate analysis results of mothers' baseline characteristics by SMM status. The bivariate comparisons by SMM status

Table 4. Characteristics among respondents with and without SMM (unweighted *N*, weighted *N* (row %), or mean ± SD) total sample = 2801.

	SMM no	SMM yes	*p*-value
PCMH			0.07
Neither	2098 3,978,035 (97.7%)	50 92,657 (2.3%)	–
Either round	474 925,490 (98.3%)	8 15,781 (1.7%)	–
Both rounds	170 349,960 (99.8%)	1 859 (0.2%)	–
Race			0.78
White	1903 4,090,185 (97.8%)	46 90,893 (2.2%)	–
Black	558 694,004 (98.0%)	10 13,881 (2.0%)	–
Asian	188 330,742 (98.7%)	3 4523 (1.4%)	–
Other	93 138,554 (100%)	0 0 (0.0%)	–
Ethnicity			0.92
Hispanic	1022 1,190,386 (97.9%)	23 25,411 (2.1%)	–
Not Hispanic	1720 4,063,098 (98.9%)	36 83,887 (2.0%)	–
Insurance coverage year 1			0.27
Public	714 1,839,452 (98.5%)	11 28,473 (1.5%)	–
Private	630 783,969 (97.1%)	17 23,481 (2.9%)	–
None	159 177,336 (98.3%)	3 3100 (1.7%)	–
Age	28.2 (SD = 5.7)	29.0 (SD = 6.2)	0.44
Marital status			0.07
Married	1277 2,928,349 (98.5%)	26 43,886 (1.5%)	–
Divorced	38 83,365 (96.6%)	2 2957 (3.4%)	–
Never married	1082 1,551,039 (98.0%)	20 32,449 (2.1%)	–
Other	345 690,731 (95.8%)	11 30,005 (4.2%)	–
Highest degree			0.95
No degree	417 507,800 (99.2%)	1 4327 (5.3%)	–
GED	75 120,798 (98.0%)	1 2471 (2.0%)	–
High school	745 1,411,662 (97.2%)	18 32,967 (2.3%)	–
4-year college	287 785,555 (98.0%)	9 15,927 (2.0%)	–
Masters or doctorate	159 443,935 (98.4%)	3 7111 (1.6%)	–
Other	428 827,464 (97.8%)	11 18,495 (2.2%)	–

(Continued)

Table 4. (Continued)

	SMM no	SMM yes	*p*-value
Family income year 1			0.32
US$0–US$25,000	1095 1,457,405 (97.3%)	26 41,110 (2.7%)	–
US$25,001–US$50,000	631 1,115,234 (98.4%)	10 18,262 (1.6%)	–
US$50,001–US$100,000	652 1,616,327 (97.6%)	18 39,027 (2.4%)	–
US$100,001 +	364 1,064,518 (99.0%)	5 10,899(1.0%)	–
BMI	27.4 (SD = 6.6)	31.3 (SD = 7.7)	0.01
OB comorbidity			0.01
No	2399 4,554,240 (98.3%)	46 78,124 (1.7%)	–
Yes	343 699,244 (95.7%)	13 31,174 (4.3%)	–
Mode of birth			< 0.01
Vaginal	1804 3,414,840 (99.2%)	12 28,153 (0.8%)	–
C-section	783 1,508,106 (95.5%)	42 70,603 (4.5%)	–

SMM: severe maternal morbidity; PCMH: patient-centered medical home; SD: standard deviation; BMI: body mass index; OB: obstetric-related; GED: General Education Development Test.
Totals may not equal 100% due to rounding.

that were significant were BMI, obstetric-related comorbidity, and mode of birth.

Main results

After identifying all variables from the bivariate analysis of the outcome of interest (SMM) with a significance value of $p \leqslant 0.2$ the final model included PCMH exposure, race, insurance coverage, marital status, BMI, obstetric-related comorbidity, and mode of birth. The PCHM exposure, and race variables did not fit these criteria, but were included in the final model because they were central to the study aims. Insurance was also included because it is independently correlated with healthcare access in the United States.[44]

Using mothers who never received PCMH care as the reference group, our results from the GEE model in Table 5 suggest an 85% decrease in the risk of SMM among mothers who were defined as always attending a PCMH (odds ratio (OR): 0.15; 95% confidence interval (CI): 0.01–1.87; $p = 0.14$) and no difference in the risk of SMM among mothers who were defined as sometimes attending a PCMH (OR: 1.00; 95% CI: 0.16–6.42; $p = 1.00$). In the exploratory analysis of any versus no PCMH exposure, we found similar results to our first GEE model where those who had any PCMH care suggest a 36% decrease in risk of SMM (OR: 0.64; 95% CI: 0.12–3.46; $p = 0.60$; see Supplemental materials). There was no overall interaction effect in the model between race and PCMH groups ($p = 0.82$; see Table 6), or ethnicity and PCMH groups ($p = 0.62$; see Table 7) on likelihood of SMM.

Discussion

This study aimed to examine the relationship between receiving PCMH care and SMM outcomes using the MEPS as the source of data. Only 7% of the total sample of mothers always received PCMH care, and 25% received at least some exposure to PCMH care. We found that mothers who always received care in a PCMH had 85% lower odds of an SMM, and mothers who sometimes received care in PCMH had no difference in the odds of an SMM. However, our findings are null and the confidence intervals are imprecise for most of the results in the final model. Regarding our secondary aim, we did not see an interaction between exposure to racism (using race as a proxy for exposure), PCMH status and SMM likely because our study was limited on the sample size of mothers who were Black, Asian, or "other" race/ethnicity during the study period and the rarity of the SMM outcome.

Although there were no statistically significant associations, these findings of having lower odds of an SMM with exposure to PCMH care are potentially clinically relevant and warrant further investigation about the possible usefulness of PCMHs as a strategy for improving maternal outcomes. When mothers have high medical and social needs, PCMH care is ideal because the patient has access to care management and social services.[45,46] This is

Table 5. Generalized estimating equation model (GEE).

	Odds ratio	95% confidence interval
Never PCMH (ref)		
Sometimes PCMH	1.00	0.16–6.42
Always PCMH	0.15	0.01–1.87
BMI	1.09	1.03–1.15
White (ref)		
Black	1.76	0.57–5.47
Asian	0.45	0.04–4.58
Other	2.86e-08	NE
Married (ref)		
Divorced	0.68	0.02–19.44
Never married	1.10	0.22–5.49
Other	4.93	0.44–54.89
Insurance coverage year 1		
Public (ref)		
Private	0.88	0.16–4.84
None	0.18	0.01–2.88
Mode of birth		
Vaginal (ref)		
C-section	24.07	2.41–240.53
OB comorbidity not present (ref)		
OB comorbidity	1.21	0.14–10.28

PCMH: patient-centered medical home; ref: reference group; BMI: body mass index; NE: not estimable; OB: obstetric-related.
Number of observations = 1549; weighted population size = 2,882,890.

Table 6. Predictive probability of severe maternal morbidity by race and PCMH status margin; (95% confidence interval).

	Never PCMH	Sometimes PCMH	Always PCMH
White	0.007; (0.005–0.009)	0.004; (0.002–0.006)	0.002; (−0.000–0.004)
Black	0.007; (0.001–0.012)	0.004; (0.000–0.007)	0.002; (−0.001–0.005)
Asian	0.005; (−0.001–0.011)	0.003; (−0.001–0.007)	0.002; (−0.001–0.004)
Other	0.000; (0.000–0.000)	0.000; (0.000–0.000)	0.000; (0.000–0.000)

PCMH: patient-centered medical home.
Interaction: $p = 0.82$.

Table 7. Predictive probability of severe maternal morbidity by ethnicity and PCMH status margin; (95% confidence interval).

	Never PCMH	Sometimes PCMH	Always PCMH
Hispanic	0.008; (0.004–0.011)	0.004; (0.001–0.007)	0.002; (−0.000–0.005)
Non-Hispanic	0.009; (0.001–0.017)	0.005; (−0.000–0.010)	0.003; (−0.001–0.007)

PCMH: patient-centered medical home.
Interaction: $p = 0.62$.

especially important for addressing social determinants of health to improve maternal outcomes.[47] To reduce adverse outcomes like SMM, prenatal care should balance between identifying medical needs and services while still providing comprehensive care, being patient-centered and accessible.[47] In other words, to improve maternal outcomes in the US healthcare systems must put the patient first by eliminating individual biases and exposure to systemic racism.

Receiving comprehensive primary care services through the PCMH model is vital to reducing the potential for preventable pregnancy-related deaths and SMM.[48] The structure of a PCMH allows patients to have an active role in the decisions made regarding their medical care. States like North Carolina, which has intentionally implemented PCMH care for their pregnant population, have seen a 6.7% reduction in low-birth-weight infants for their Medicaid population.[46] Our study suggests that the PCMH

model may be effective in reducing the odds of SMM, and further research is needed to confirm these findings.

It is important that clinical practitioners and policymakers acknowledge that sociodemographic factors are not always a marker for adverse health outcomes. In fact, race should be regarded as a proxy marker for exposure to structural inequities and racism that can impact health.[13,14] Lower socioeconomic status is frequently associated with poor health outcomes throughout the literature. In a landmark study conducted in 1992, comparing Black and White college educated females, the Black graduates had a 1.67 higher risk of preterm birth and 2.48 higher risk of delivering a low-birth-weight newborn.[49] Similar findings continue to be demonstrated in recent large population-based cohort studies investigating racial disparities in maternal outcomes[50] and in annual reports by organizations such as March of Dimes.

Throughout the literature, BMI is also a factor that is frequently associated with poor health outcomes especially in maternal health studies. For example, studies have shown that both high and low gestational weight gain is modestly associated with the risk of SMM.[51] Other studies have revealed that comorbidities and cesarean mode of birth explained the relationship between high pre-pregnancy BMI and SMM.[52] Both studies demonstrated the need to improve current trends in obesity across America. To address outcomes such as SMM, future studies must shift the focus to analyzing social determinants of health (e.g. healthcare access, socioeconomic disadvantage, community resources) and the multi-level drivers of maternal health inequities. Although mode of birth and obstetric-related comorbidity were significant predictors of SMM, these variables had wide confidence intervals, which indicates our sample may not be an accurate representation of the population mean for these predictors.

Limitations

Although PCMH care was defined by participant responses using a previously validated method,[37–40] this may or may not represent an actual medical home effect. The MEPS does not explicitly ask an item to identify whether the respondent receives care at a designated/accredited medical home. Similar limitations are noted in other PCMH studies utilizing this dataset.[17,18,37] The final GEE model only included 55% of the original sample because insurance data was missing for a large proportion of mothers. This also points to the limitation that these results may not be generalizable to the US population.

Our univariate analysis of SMM did not find a racial disparity in the SMM outcome, and White mothers had non-significantly higher rates of SMM compared to other racial groups. We were unable to detect a difference of the effect of participating in a PCMH on the SMM outcome. It is well documented that there is strong evidence of racial disparities in SMM outcomes[53,54] linked to exposures to racism,[55] however, we did not find such an association possibly because the MEPS did not oversample for racial/ethnic mothers who had a birth event during the study period. This could also be due to the small number of MEPS participants who experienced the outcome of interest. Again, illuminating to the fact that the findings of this study may not be generalizable to the US population. Further research is necessary to investigate the relationship between race/ethnicity, PCMH status, and predicted probability of SMM especially with the use of nationwide datasets where the results can be generalized to the US population.

Our study had appropriate statistical power, however, a SMM is a rare outcome. Predicting rare events in a model can be difficult. Severe maternal morbidities such as eclampsia, cardiac disease or amniotic fluid embolism are very rare maternal conditions and in hospital discharge data these conditions are typically underreported.[56] Although the MEPS provides medical condition files on household-reported conditions, there is a risk of the respondent underreporting conditions. The overall rate of SMM (2%) within our study was similar to national trends in the US population where data show that approximately 1 to 2% of birthing people experience an SMM each year.[10,57]

Our findings did not replicate prior studies that demonstrated reduction of racial disparities with the implementation of PCMH[58,59] possibly due to underreporting of primary care experiences by mothers. In a qualitative study of healthcare disparity stakeholders (e.g. patient advocates, primary care practices, researchers), participants stated that more efforts need to be made to heighten the awareness of healthcare disparities when designing PCMH policies and implementing PCMH care.[60] Recently government reports have been released to stress that additional research is needed on innovative models of care that can reduce adverse outcomes in racial/ethnic minoritized mothers.[61] Models of care are a service in healthcare based on evidence-based practice, theory and standards guided by a framework that outlines how care should be applied and evaluated.[62]

Another limitation is the CDC definition of SMM as compared to the publicly available MEPS ICD 9/10 codes for medical conditions and the way medical conditions are grouped into CCC in MEPS. The publicly accessible ICD 9/10 codes from the MEPS are limited to the first three digits, and depending on the condition, this may lead to misclassification of an SMM or obstetric-related comorbidities. A disadvantage of using CCC is that some outcomes are coded into a "catch-all" grouping variable labeled an "other complication of birth." To that end, we did not include this code in the identification of SMM. However, we did use this grouper code for obstetric-related comorbidity classification, but we were unable to identify the direction of potential misclassification. Despite this limitation, we were

able to identify a 2% rate for SMM that is similar to previously published national estimates.[10,57]

Finally, the MEPS does not link mothers to neighborhood characteristic measures, thus making it difficult to draw conclusions about access to care by individual states or counties. Future studies can pursue the linking MEPS data to census track records. As survey weights were applied for this study, the MEPS data are a robust survey that is nationally representative of the US population.

Implications for practice and/or policy

This study provides limited evidence to support the implementation of PCMH practices into maternal care. More evidence is needed to measure the effect of PCMH on maternal outcomes for racial and ethnic groups. The investigation of social determinants of health must be prioritized in order to achieve equitable maternal healthcare. What this study also shows is the need for data that identifies population-level characteristics and definitive information about participation in a PCMH on national scale.

Conclusion

Overall, our study findings show that mothers who had at least some exposure to a PCMH had 49% to 92% lower odds of experiencing an SMM compared to those who were never in a PCMH. While this finding approached statistical significance, more research is needed to examine the ways in which the PCMH model may be beneficial to improving SMM outcomes. In addition, there was no interaction effect of race/ethnicity by PCMH status on the SMM outcome. Despite this finding, there is evidence that disparities in SMM outcomes exist. We most likely did not see an interaction between exposure to racism (using race as a proxy for exposure), PCMH status and SMM because we were predicting a rare event. When there is more evidence of participation in a PCMH, we may be able to draw more accurate conclusions on its impact regarding disparate outcomes.

Declarations

Ethics approval and consent to participate

The study meets the Not Human Subject criteria set forth by the Code of Federal Regulations (45 CFR 46) of (a) the specimens and/or private information/data were not collected specifically for the currently proposed research project through an interaction/intervention with living individuals; and (b) the investigator(s) including collaborators on the proposed research cannot readily ascertain the identity of the individual(s) to whom the coded private information or specimens pertain.

Consent for publication

Not applicable.

Author contribution(s)

Curisa M Tucker: Conceptualization; Formal analysis; Investigation; Methodology; Writing—original draft; Writing—review & editing.
Nathaniel Bell: Conceptualization; Methodology; Writing—review & editing.
Cynthia F Corbett: Conceptualization; Methodology; Writing—review & editing.
Audrey Lyndon: Conceptualization; Methodology; Writing—review & editing.
Tisha M Felder: Conceptualization; Methodology; Writing—review & editing.

Acknowledgements

The primary author would like to acknowledge the co-authors of this manuscript who served as mentors during the completion of this work toward her dissertation.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Competing interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Availability of data and materials

The MEPS data are publicly available. Data extraction, merging, and grouping algorithms using different software packages can be found online at: https://github.com/HHS-AHRQ/MEPS.

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Supplemental material

Supplemental material for this article is available online.

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