Trends in stress among pregnant and postpartum women during the COVID-19 pandemic

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Abstract

Background: Stress has been associated with adverse birth and postpartum health outcomes. Few studies have explored racial differences in maternal stress in a birthing population longitudinally in the United States (U.S.) during the ongoing COVID-19 pandemic.

Objective: This study aimed to: (1) assess changes in reported stress before, during, and after initial emergency declarations (e.g., stay-at-home orders) were in place due to the COVID-19 pandemic and (2) assess Black-White differences in reported stress in a pregnant and postpartum population from Southwestern Pennsylvania.

Methods: We leveraged data from the ongoing Postpartum Mothers Mobile Study (PMOMS) which surveys participants in real-time throughout the pregnancy and postpartum periods via ecological momentary assessment (EMA) and smartphone technology. We analyzed data from a subset of PMOMS participants (n=85) who were either Black or White, and who submitted EMA responses regarding stress between November 1, 2019 and August 31, 2020, the timeframe of this study. Data were divided into four phases based on significant events during the COVID-19 pandemic: a pre-phase (baseline), early-phase (first case of COVID-19 reported in U.S.), during-phase (stay-at-home orders), and post-phase (stay-at-home orders eased). We assessed mean stress levels at each phase using mixed-effects models and post-hoc contrasts based on the models.

Results: Overall mean stress (min: 0, max: 4 as measured by a modified Cohen Perceived Stress Scale) during the pre-phase was 0.8 for Black and White participants [range for Black participants: 0-3.9, range for White participants: 0-2.8]. There was an increase of 0.26 points (t=5.19, d.f.=5649, p<.0001) in the during-phase as compared with the pre-phase, and an increase of 0.19 points (t=3.09, d.f.=5649, p=0.002) in the post-phase compared with the pre-phase (n=85). No difference was found between Black and White participants in the change in mean stress from the pre-phase to the during-phase (? ?= -0.016, p=0.867). There was a significant difference between Black and White participants in the change in mean stress from the during-phase to the post-phase (? ? = -0.39, p<0.0001).

Conclusions: There was an overall increase in mean stress levels in this subset of pregnant and postpartum participants during the same time as the emergency declarations/stay-at-home orders in the US. Compared to baseline, mean stress levels remained elevated when stay-at-home orders eased. We found no significant difference in the mean stress levels by race. Given that stress is associated with adverse birth outcomes and postpartum health, stress induced by the ongoing COVID-19 pandemic may have

adverse implications for birthing populations in the U.S.

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Conclusions: There was an overall increase in mean stress levels in this subset of pregnant and postpartum participants during the same time as the emergency declarations/stay-at-home orders in the US. Compared to baseline, mean stress levels remained elevated when stay-at-home orders eased. We found no significant difference in the mean stress levels by race. Given that stress is associated with adverse birth outcomes and postpartum health, stress induced by the ongoing COVID-19 pandemic may have adverse implications for birthing populations in the U.S.

Keywords: COVID-19; Ecological Momentary Assessment; Health Status Disparities; Pandemics; Postpartum; Pregnancy; Stress, Psychological

Introduction

By late 2019, the world had become increasingly aware of the novel coronavirus, COVID-19 (the disease caused by SARs-cov2). The first case of the coronavirus in the United States (U.S.) was identified in the state of Washington on January 21, 2020[1]. Shortly thereafter, the U.S. Secretary of Health and Human Services declared a public health emergency on January 31, 2020 [2]. On March 11, 2020, the World Health Organization (WHO) declared COVID-19 a pandemic, signifying that cases of the virus had spread to more than one hundred countries [3]. Two days later, the U.S. federal government declared the pandemic a national emergency [2]. On March 16, 2020, the U.S. President and the White House Coronavirus Taskforce members presented guidelines to slow the spread of the virus during a press conference targeted to the U.S. public. These guidelines included listening to local authorities, staying at home if sick, and isolating if someone in your household tested positive for the virus [4]. This was federal guidance, but much of the public health intervention needed to address the outbreak was left to local officials. Since there was limited federal intervention initially to address the outbreak, the response to the coronavirus varied by parishes, counties, states, and regions across the country.

In the initial stages of the pandemic, local government officials had limited tools, knowledge, and resources to address the public's concern about the virus and to mediate risk to the public. Furthermore, this was a new coronavirus, which impeded the U.S. development and scaling up of diagnostic tests to confirm diagnoses of the virus [5]. Additionally, inconsistent health communication to the public regarding how individuals contracted the virus as well as symptoms, left the public vulnerable to contracting the virus [6]. Since local officials had limited resources to test for the virus and isolate infected individuals, they used other methods to reduce the risk of disease to the public. To slow the spread of the virus and to mitigate overburdening the healthcare system, some government officials across the nation declared a state of emergency and issued stay-at-home orders as a public health intervention to break the chain of infection from person-to-person contact. These emergency declarations and policy actions included temporary business closures [7], movement of education to online/remote formats [8,9], and changes in healthcare system protocols [10]. Employment was affected among the 20.4% of U.S. workers employed in industries impacted by some state and local business restrictions aimed at reducing the spread of the virus [11]. In April 2020, employment payrolls fell by 20.5 million people and the unemployment rate was 14.7% [12]. Moreover, uncertainty about the virus and limited mechanisms to mediate the risk to the public greatly disturbed the daily lives of U.S. residents.

Experts have seen a global increase in the incidence of anxiety, depression, post-traumatic stress disorder (PTSD), and psychological distress in the general population during the pandemic [13]. Czeisler et al. [14] used representative panel surveys (administered June 24-30, 2020) to assess mental health, substance use, and suicidal ideation among U.S. adults. Of their respondent sample, 40.9% of adults reported at least one adverse mental health condition (symptoms of anxiety or depressive disorder) and 30.9% reported symptoms of trauma or stressors related to the pandemic. Moreover, young adults, Hispanic persons, Black persons, essential workers (i.e., healthcare workers), unpaid caregivers for adults, and persons receiving treatment for preexisting psychiatric disorders were disproportionately impacted by adverse mental health due to the pandemic [14]. Park et al. [15] found common stressors related to COVID-19 included media coverage of viral contagiousness, uncertainty about the length of quarantine or social distancing measures, disruption to social and personal care routines, lack of job security and financial strain, and perceived risk of infection among a sample of U.S.

adults. This study also found that individuals with caregiver status, younger adults, sexual minorities, and non-White participants were at greater risk for stressors related to the pandemic [15]. Thus, several stressors related to uncertainty about the pandemic impacted populations in the U.S., which was felt disproportionately among marginalized communities (i.e., Black people, LGBTQ people), and individuals experiencing adverse mental health prior to the pandemic.

Given that psychological stress is associated with adverse birth outcomes and maternal health, stress induced by the COVID-19 pandemic may have implications for perinatal and birthing populations in the US. Several international studies have reported an increase in psychological stress and psychiatric symptoms during the COVID-19 pandemic among childbearing populations; however, few studies are based in the U.S. [16-18]. Preis et al. [19] found that pregnant people in the U.S. (recruited late April 2020) reported mild (35.6%), moderate (21.6%), and severe (21.7%) anxiety. Using a pandemic-related stress (PREPS) scale, they found that pandemic preparedness stress (OR=1.75,95% CI 1.35-2.26), and anxiety related to perinatal COVID-19 infection stress (OR= 1.55, 95% CI 1.28-1.88) were associated with a greater likelihood of moderate or severe anxiety symptoms after adjustment for sociodemographic, medical, and obstetrical variables. In a follow-up study, (conducted April-May, 2020) pandemic preparedness stress (30%) and perinatal infection stress (27.2%) were associated with income loss, prenatal care disruption, and perceived COVID-19 infection among pregnant people [20]. A mixed-methods study conducted March to April of 2020 found that 60% of surveyed pregnant participants (n=27) reported experiencing moderate or severe anxiety symptoms and 68% reported moderate stress. In the qualitative results (n=31), participants reported uncertainty related to prenatal care, stress related to the risk of COVID-19 infection, disruption of birth plans, and lack of postpartum support [21]. One study also found that over 50 percent of pregnant participants reported increased stress related to food insecurity, loss of job or household income, and loss of childcare [22]. Another study found COVID-19 health worries (e.g., fear of infection) and grief (e.g., loss of meaningful experiences) was associated with clinically significant levels of depression, generalized anxiety, and PTSD among pregnant and postpartum participants. This study also found that participants who reported pre-existing mental illness diagnoses were more likely to report these symptoms [23]. These studies suggest that stress related to lack of support, income loss, uncertainty regarding prenatal/postnatal care, perceived risk of COVID-19 infection, and inability to meet basic needs (e.g., securing food) were associated with reports of increased stress and symptoms of mental health illnesses among U.S. perinatal populations. Prior studies based in the U.S. have not examined longitudinal changes in stress among perinatal populations by race, thus creating the impetus to examine these experiences in this population.

Objective of Study

This study examined changes in reported stress during different phases of the pandemic in a sample of U.S. pregnant and postpartum people. The aims of this manuscript are to: (1) assess changes in reported stress before, during, and after initial emergency declarations/stay-at-home orders were in place and (2) assess whether reported stress differed by race during these time periods over the COVID-19 pandemic.

Hypotheses

We hypothesized that: (1) all participants would report higher mean stress levels in the during-

phase compared with the pre-phase; (2) in the post-phase, reported mean stress levels would return to pre-phase levels for all participants; and (3) reported mean stress levels would increase for all participants from the pre-phase to the during-phase, but the change in reported stress levels would be higher for Black participants than for White participants.

This study is a secondary analysis of data from the Postpartum Mothers Mobile Study (PMOMS), a prospective longitudinal study examining factors associated with racial disparities in postpartum weight retention and cardiometabolic health. PMOMS uses smartphone technology to remotely collect survey data via ecological momentary assessment (EMA). EMA allows for the assessment of study participants experiences, moods, and behaviors in the context of their natural environment and in real time [24]. The EMA component of PMOMS enabled the continuation of primary data collection during the COVID-19 pandemic, since participants answered survey questions via the smartphone. Further details about the study are published elsewhere [25,26].

Methods

Study Design

PMOMS is an ancillary study to GDM2 (Comparison of Two Screening Strategies for Gestational Diabetes) [27,28], a randomized controlled trial conducted in a single Women's hospital in Southwestern Pennsylvania. In addition to the participants recruited to PMOMS from the GDM2 clinical trial (n=284), participants were also directly recruited into the PMOMS study (n=29). The study participants are recruited during the second and third trimester (18 to 28 weeks' gestation) and followed up to 1 year postpartum. Once participants consented to the study, they completed baseline surveys, received smartphones, a smart scale, and downloaded a companion app to weigh themselves. Participants completed EMA surveys throughout the duration of the study. PMOMS was approved by the Human Research Protection Office at the University of Pittsburgh.

Setting & Participants

A subset of participants from PMOMS contributing data from November 1, 2019-August 31, 2020 served as the analytic sample (n=85). We divided the study period into four phases based on significant events in the COVID-19 pandemic timeline in the U.S., Pennsylvania, and Allegheny County. Most of the study participants (n=81) lived in Allegheny County during the study period. The "pre-phase" (Nov. 1, 2019-Jan. 20, 2020; 81 days) represents a reference baseline period before the first case of COVID-19 in the U.S. The "early-phase" (Jan. 21, 2020-March 12, 2020; 52 days) began on the first day a COVID-19 case was reported in the U.S. [1]. The "during-phase" (March 13, 2020-June 4, 2020; 84 days) began on the day COVID-19 was declared a national emergency and Pennsylvania officials implemented state-wide stay-at-home orders (closure of all businesses that were not life sustaining) [29]. This period also included remote and online educational learning for public schools, business closures, and the issue of stay-at-home orders specifically in Allegheny and surrounding counties [30]. The "post-phase" of this study (June 5, 2020-Aug. 31, 2020; 88 days) covered the transition from previous stay-at-home orders to the restricted opening of non-essential businesses (i.e., bars, gyms) in Allegheny County (see Figure 1).

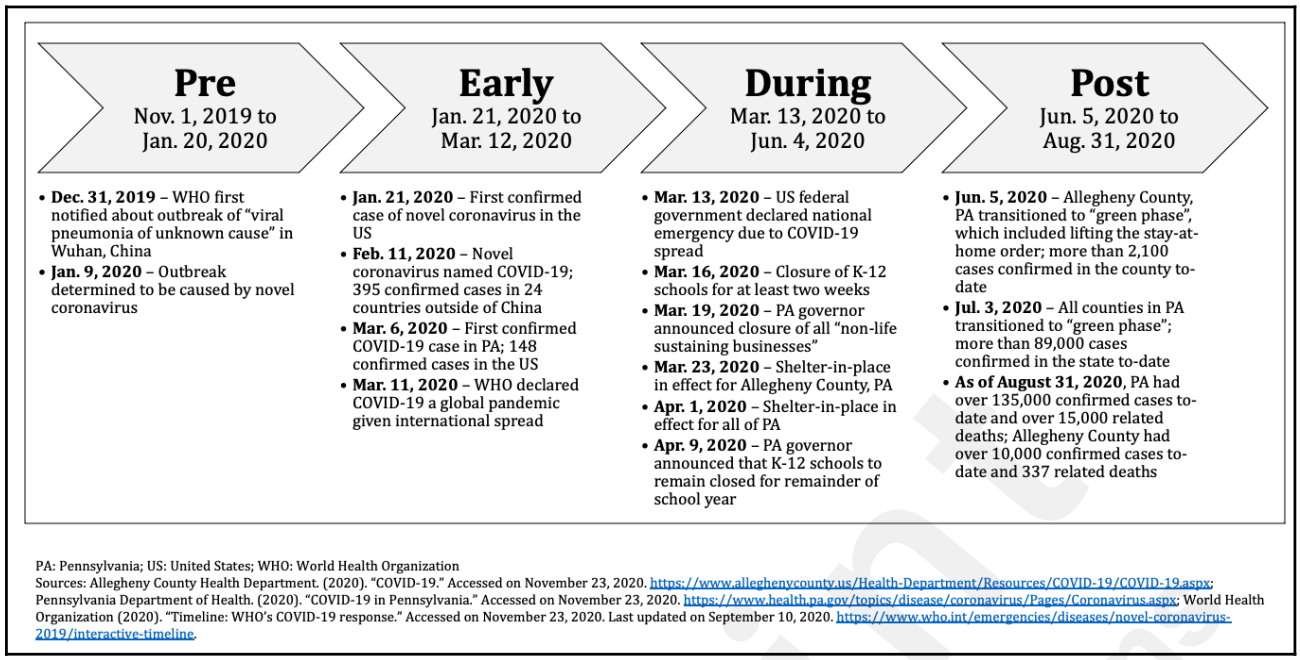

Figure 1. Phases of COVID-19 response as applied in the present analysis, based on administrative actions at the national, state, and county levels.

Measurements

Primary Outcome

The primary outcome of interest in this study was mean reported stress levels measured using a modified Cohen Perceived Stress Scale collected via EMA [31]. EMA data were collected using signal-contingent and time-contingent prompts on participant smartphones. The participants chose the timing of beginning of day (BOD) and end of day (EOD) surveys, there were at least nine hours between these time-contingent prompts. The BOD and EOD surveys included questions about sleep, mood, and dietary intake. The signal-contingent prompt used a random sampling design (described in detail elsewhere [25]) to administer random daily surveys that included questions about mood, stress, self-efficacy, microaggressions, race, and gender discrimination [26]. At the beginning of each random survey, participants were asked to "rate if you are feeling nervous or stressed right now?" The response scale ranged from 0 (not at all) to 4 (a lot), which was used for these analyses.

Main Predictors

The main predictors in the model were pregnancy or postpartum, race, and phase of the COVID-19 pandemic timeline, the latter of which is described in detail above.

Participants self-reported race via self-administered electronic surveys at the baseline visit (18-28 weeks' gestation).

Covariates

We selected covariates based on the literature and our understanding of stress during pregnancy [32,33]. Education level, employment status, household income, and marital status were included as covariates. All covariates were dichotomized, with education dichotomized as less than college vs. college degree or higher, employment status as unemployed vs. employed,

household income as earning less than $50,000 per year vs. over $50,000 per year, and marital status as unmarried vs. married.

Analytical Sample

The overall PMOMS population included 313 participants. Out of these, 197 completed PMOMS prior to the timeframe of this study (November 1, 2019-August 31, 2020), leaving a total of 116 participants. Out of those, 24 did not complete EMA surveys with stress data, resulting in 92 participants with stress data. We excluded participants that identified as Asian (n=5) or more than one race (n=2) since our primary aim was to examine Black-White differences in stress levels during the study period, resulting in a total of 85 participants in the final analytic sample. The analytical sample included participants that self-identified as White (n=53), Black or African American (n=31), and African (n=1) who completed EMA surveys. The participants included in the analytic sample were more likely to be White, married, college educated, employed full-or- part-time, and had a household income $50,000 or higher compared to participants that were excluded.

Statistical Methods

Participants were included in a phase if they contributed at least one survey during that phase. Not all participants contributed surveys in every phase. Descriptive analyses included estimates of frequencies of categorical demographic covariates including race, education level, employment status, household income, and marital status; mean numbers of signal-contingent survey responses contributed per participant in each of the four phases (overall and by race), and unadjusted mean stress levels in each of the four phases (overall and by race). Variance inflation factors (VIFs) were used to assess the multicollinearity among education, income, employment, and marital status. Since all VIFs were less than 5, all covariates were included in the model.

Mixed-effects models with random subject effects were used to describe the effect of COVID-19-related emergency declarations/stay-at-home orders on repeated measured stress levels in signal contingent assessments. All models included main effects for pregnancy stage, race, and study phase, and an interaction between race and study phase. Since the literature shows that marital status, employment, education, and income are important factors associated with stress during pregnancy, we explored models including these covariates as fixed effects. F-tests were used to determine the significance of fixed effects. Adjusted mean stress levels were computed for each model, and post-hoc contrasts based on the models were used to address the study aims. All analyses were conducted using SAS® version 9.4 (SAS Institute Inc. Cary, NC).

Results

As participants completed the PMOMS study, the sample size declined across COVID-19 phases. One African American participant withdrew from the study but contributed survey data to the pre-phase prior to doing so. Baseline demographic characteristics of the study participants who contributed EMA data in each phase are presented in Table 1. The study sample was mostly White (62.4%), married (56.5%), had a college degree or higher (51.8%), was employed full- or part-time (74.1%), and had an income greater than $50,000 (50.6%). The percentage of Black

participants contributing to the data in each phase ranged between 34.3% and 41.7%, whereas the percentage of White participants ranged between 58.3% and 65.7%.

Table 1. Frequencies of participants contributing data in each phase by demographic variable[a], and stratified by Black[b] and White Race. Percentages (given in parentheses) are over all participants contributing data in a given phase.

	All (N=85)		**Pre Phase (n=66)**		**Early Phase (n=52)**		**During Phase (n=35)**		**Post Phase (n=24)**	
	Black (n=32) (37.6%)	White (n=53) (62.4%)	Black (n=23) (34.9%)	White (n=43) (65.2%)	Black (n=19) (36.5%)	White (n=33) (63.5%)	Black (n=12) (34.3%)	White (n=23) (65.7%)	Black (n=10) (41.7%)	White (n=14) (58.3%)
Hispanic										
	0 (0.0)	3 (3.53)	0 (0.0)	3 (4.55)	0 (0.0)	1 (1.92)	0 (0.0)	1 (2.86)	0 (0.0)	0 (0.0)
Current student										
	3 (3.53)	4 (4.71)	3 (4.55)	4 (6.06)	1 (1.92)	2 (3.85)	1 (2.86)	1 (2.86)	0 (0.0)	0 (0.0)
College degree or higher										
	6 (7.06)	38 (44.7)	5 (7.58)	31 (47.0)	2 (3.85)	26 (50.0)	2 (5.71)	18 (51.4)	1 (4.17)	11 (45.8)

Currently employed										
	18 (21.2)	45 (52.9)	17 (25.8)	35 (53.0)	9 (17.3)	29 (55.8)	3 (8.57)	19 (54.3)	1 (4.17)	13 (54.2)
Household Income > $50,000										
	3 (3.53)	40 (47.1)	3 (4.55)	32 (48.5)	1 (1.92)	26 (50.0)	1 (2.86)	18 (51.4)	0 (0.0)	11 (45.8)
Married										
	6 (7.06)	42 (49.4)	5 (7.58)	33 (50.0)	2 (3.85)	29 (55.8)	2 (5.71)	20 (57.1)	1 (4.17)	12 (50.0)

[a]All covariates were measured at baseline.
[b]Black defined as Black/African American or African

Table 2 displays the mean number of EMA surveys contributed by participants overall and in each phase, stratified by race. White participants contributed a higher mean number of surveys overall (mean=63.7) and in each phase (mean range: 25.2-57.9) compared with Black participants (overall mean=43.9; mean range: 15.4-26.1).

Table 2. Distribution of number of completed surveys per participant, by phase and race (N=85).

Phase	Race	Mean	Median	Min	Max
All					
	Black (n=32)	43.9	33	1	153
	White (n=53)	63.7	55	1	199
Pre					
	Black (n=23)	26.1	25	1	74
	White (n=43)	36.3	38	2	75
Early					
	Black (n=19)	15.4	13.0	1	34
	White (n=33)	25.2	23.0	3	49
During					
	Black (n=12)	25.0	18.5	1	59
	White (n=23)	47.7	58.0	2	73
Post					
	Black (n=10)	24.5	20.0	3	61
	White (n=14)	57.9	62.5	1	87

The distribution of unadjusted mean stress levels for Black and White participants are shown in Table 3. This includes the overall mean stress levels between Black and White participants with no difference during the pre-phase but differences are observed at each of the other phases.

Table 3. Distribution of unadjusted mean stress levels by phase and race (N=85).

Phase	Race	Mean	Min	Max
Pre				
	Black (n=23)	0.8	0	3.9
	White (n=43)	0.8	0	2.8
Early				
	Black (n=19)	0.8	0	2.9
	White (n=33)	0.9	0	2.7
During				
	Black (n=12)	1.4	0	4.0
	White (n=23)	1.1	0	4.0
Post				
	Black (n=10)	0.5	0	1.8
	White (n=14)	1.3	0.1	4.0

Stress Outcomes

In our first analysis of stress over the study period, we found a significant race and phase interaction ($F_{1,3}$=14.8,p<0.0001). Figure 2 shows the mean stress levels for Black and White participants, adjusted for phase, race, the phase by race interaction, marital status, income, education, and employment.

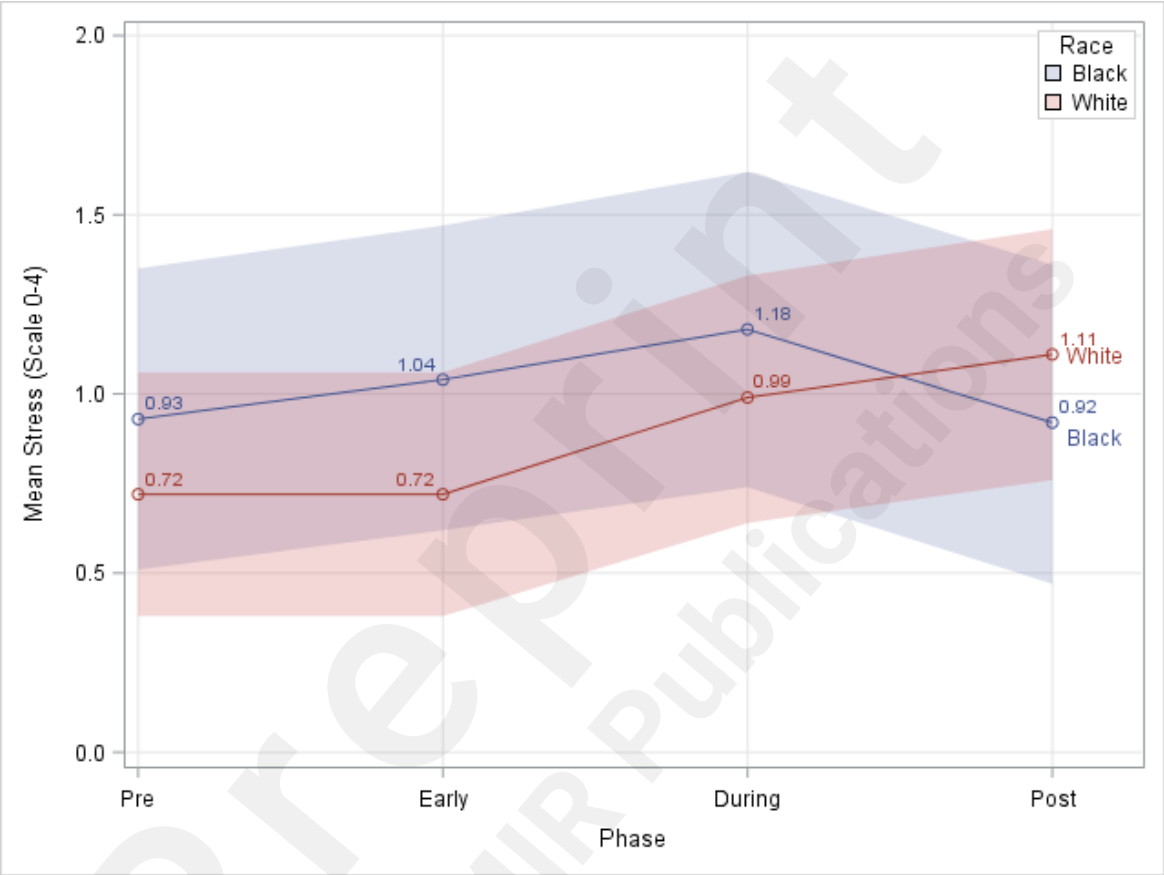

Figure 2. Mean Level of Stress for Each Phase by Race, Adjusted for marriage, education level, employment, and income level.

Post-hoc contrasts regarding all participants, based on the mixed-effects model, showed an increase in mean stress-levels of 0.26 points (t=5.19, d.f.=5649, p<.0001) in the during-phase as compared with the pre-phase, and an increase of 0.19 points (t=3.09, d.f.=5649, p=0.002) in the post-phase compared with the pre-phase (Table 4).

Table 4. Phase-to-phase comparison of mean stress, adjusted for covariates.

Phase Comparison	Difference in Adjusted Mean Stress	SE	t Value	Pr > |t|
During to Pre				
	0.26	0.05	5.21	<.0001
Post to Pre				
	0.19	0.06	3.10	0.0020
Model 2: Stage, Race, Phase, Race x Phase Interaction, married, education level, employed, income level d.f.=5649				

Adjusted analyses showed that there was no difference between Black and White participants in the change in mean stress from the pre-phase to the during-phase ($\hat{\delta}$ = -0.016, p=0.867). The results of the adjusted analyses were very similar to those of the unadjusted model ($\hat{\delta}$ = -0.020, p=0.831).

Given the significant race and phase interaction and the mean-stress trajectories in Figure 2, which show that mean stress increased between the during- and post-phases for White participants and decreased for Black participants between these phases, we conducted an ancillary analysis focused on a final contrast between Black and White participants regarding the change in reported stress levels between the during- and post-phases. There was a significant difference between Black and White participants in the change in mean stress from the during-phase to the post-phase ($\hat{\delta}$ = -0.39, p<0.0001).

Discussion

Principal Results

We found there was an increase in mean reported perceived stress levels during initial emergency declarations and stay-at-home orders in Allegheny County, Pennsylvania compared to the baseline measure of stress (pre-phase) among study participants. This finding supports our first hypothesis that participants would report increased stress levels during the period of initial emergency declarations/stay-at-home orders (during-phase) enacted to mitigate the risk of infection of COVID-19 to the public due to limited knowledge and resources to address the outbreak. The second hypothesis indicated that reported stress levels would return to baseline (pre-phase) during the post-phase (when stay-at-home orders eased), and residence could resume some of their normal daily activities. However, we found that stressed levels remained elevated during this period and did not return to baseline. Our third hypothesis anticipated that Black participants would report higher stress levels from the pre-phase to the during-phase than White participants based on previous studies that indicate Black people report higher stress levels during pregnancy than non-Black people [34,35]. We found no significant difference in mean stress level between Black and White participants during the (pre-, early-, and during) phases of the study. We also found that only Black participants' mean levels of stress were near baseline levels during the post-phase. In fact, mean stress levels among White participants increased

in each phase of the study (pre-, early-, during-, and post), and did not return to baseline levels. In our ancillary analysis we found a significant Black-White difference in mean stress levels from the during to the post-phase, when mean stress levels decreased for Black compared to White participants.

Previous studies found that Black birthing people experience more stress during pregnancy than White birthing people. One prior study found that Black participants reported higher levels of stress and had higher biomarkers of stress (i.e., corticotropin-releasing hormone, adrenocorticotropic hormone) in late pregnancy than White participants [34]. Another study found that Black primigravida participants experience a threefold increased risk for PTSD symptoms compared with non-Black participants [35]. Maternal stress is a key factor in understanding adverse pregnancy and birth outcomes. Therefore, understanding Black-White differences in maternal stress in the context of the COVID-19 pandemic could have implications for reproductive and infant health outcomes.

Existing literature may help explain why Black participants in our study did not experience more stress than White participants. Two studies found that working from home, spending more time with a new baby, saving money, managing expectations, access to outside spaces, and healthy behaviors were all positive coping mechanisms among U.S. pregnant and postpartum people during the pandemic [20,21]. Racial differences in protective factors and coping mechanisms against stress may explain lower reports of stress among Black participants in our study. The coping style and response to stressful events as “strong” or with strength has been identified as a coping mechanism or cultural expectation among Black women in several studies [36-39]. Moreover, this coping mechanism may persist in this sample of Black participants during the pandemic. An alternative explanation is there may be racial differences in completion rates of surveys. However, we do not know if this was an effect of the pandemic or a true racial difference. Further work is necessary to establish whether coping styles and practices contribute to racial differences in reported stress in perinatal populations during the pandemic and what protective factors are most beneficial to different populations.

The psychological, economic, and other short-term and long-term consequences of the impact of COVID-19 are still emerging and provide a template for handling similar circumstances in the future. During our study period, the U.S. public experienced different risk levels-based on community spread of the virus and anticipated surges of cases without a vaccine or treatment to sufficiently reduce risk of illness or death. Additionally, unemployment—even briefly—may have longer-term financial consequences as families recover from income loss, and the risk of housing insecurity due to lack of income. As noted from the COVID-19 pandemic in the U.S., even as restrictions on non-essential businesses eased, the easing of restrictions was not a panacea. The unemployment rate was 8.4% when public health related restrictions eased in August 2020, which was still 4.9 percentage points higher than it was in February 2020, prior to any implementation of stay-at-home orders [40]. Additionally, parents who continued to work during stay-at-home orders, returned to work, or telecommuted as a work option potentially experienced challenges to childcare due to the uncertainty in reopening schools, remote learning for children, and disruptions in other childcare options [9,41]. These factors as well as loss of household

income, difficulty meeting basic needs (i.e., rent/mortgage), and other unmet needs (i.e., food insecurity) may contribute to experiences of stress. Moreover, the inability to cope with these unmet needs among childbearing people due to COVID-19 has the potential to exacerbate experiences of stress.

Limitations

We are aware that our study findings have some limitations. First, this study did not collect data on changes in sociodemographic information overtime, but baseline measures provided some indication of participants' status. One of our key findings is that stress increased among White participants during each study phase. Since sociodemographic information was not collected longitudinally, we cannot state whether these factors contributed directly to the increase in stress in this sample of participants. Second, our overall sample size decreased over each phase of the study, especially for Black participants. Also, Black participants contributed fewer surveys throughout the study period, and their responses were the lowest in the post-phase. Our findings indicated that Black participants' mean stress levels returned to baseline during the post-phase. Lower survey responses among Black participants throughout the study period could bias findings, especially if the reduction in response rates was due to experiences of stress during the study period. Finally, since our sample was drawn from one county served by one maternity hospital in Pennsylvania, our findings may not be generalizable to other settings.

Strengths

Several strengths of this study should be noted. The participants were already enrolled in an ongoing longitudinal study, which allowed for the examination of stress over significant phases of the COVID-19 pandemic in the U.S., and in a diverse population in southwestern Pennsylvania in particular. The use of EMA data collection methods and smartphone technology provided survey responses in real-time and in the social context of the participants. Additionally, random signal-contingent assessments use a random sampling design to provide a representative sample of participants' survey responses over the study interval. Moreover, survey responses collected in real time via smartphone technology provided insight into participants' experiences of stress during the initial emergency declarations related to the pandemic and stay-at-home orders intended to reduce the risk to the public.

Conclusions

In this paper we explored racial differences in stress over time among childbearing people during the COVID-19 pandemic using EMA data collection methods via smartphone technology. To our knowledge, this is the first study using these methods to examine stress over time in a diverse U.S. sample of childbearing people. Evidence from this study suggests there are racial differences in experiences of stress during the pandemic. Moreover,

differences in socioeconomic status, and support systems such as marriage may influence the degree of the impact of COVID-19. The impact of COVID-19 on U.S. residents is ongoing and the risk of infection is still a public concern. Our research highlights the need for medical and public health practitioners to understand stress among perinatal populations during an ongoing pandemic and public health emergency, so they know how to intervene to reduce adverse maternal health outcomes. Ongoing research is needed to understand the enduring and long-term impact of COVID-19 on childbearing individuals in the U.S., and how to address these concerns for different populations.

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Conflicts of Interest

Dr. Esa Davis is a member of the United States Preventive Services Task Force (USPSTF). This article does not necessarily represent the views and policies of the USPSTF.

Abbreviations

BOD: Beginning of Day
EMA: Ecological momentary assessment
EOD: End of Day
GDM[2]: Comparison of Two Screening Strategies for Gestational Diabetes (GDM2) Trial
LGBTQ: Lesbian, Gay, Bisexual, Trans & Queer
PMOMS: Postpartum Mothers Mobile Study
PTSD: Post-Traumatic Stress Disorder
VIF: Variance Inflation Factors

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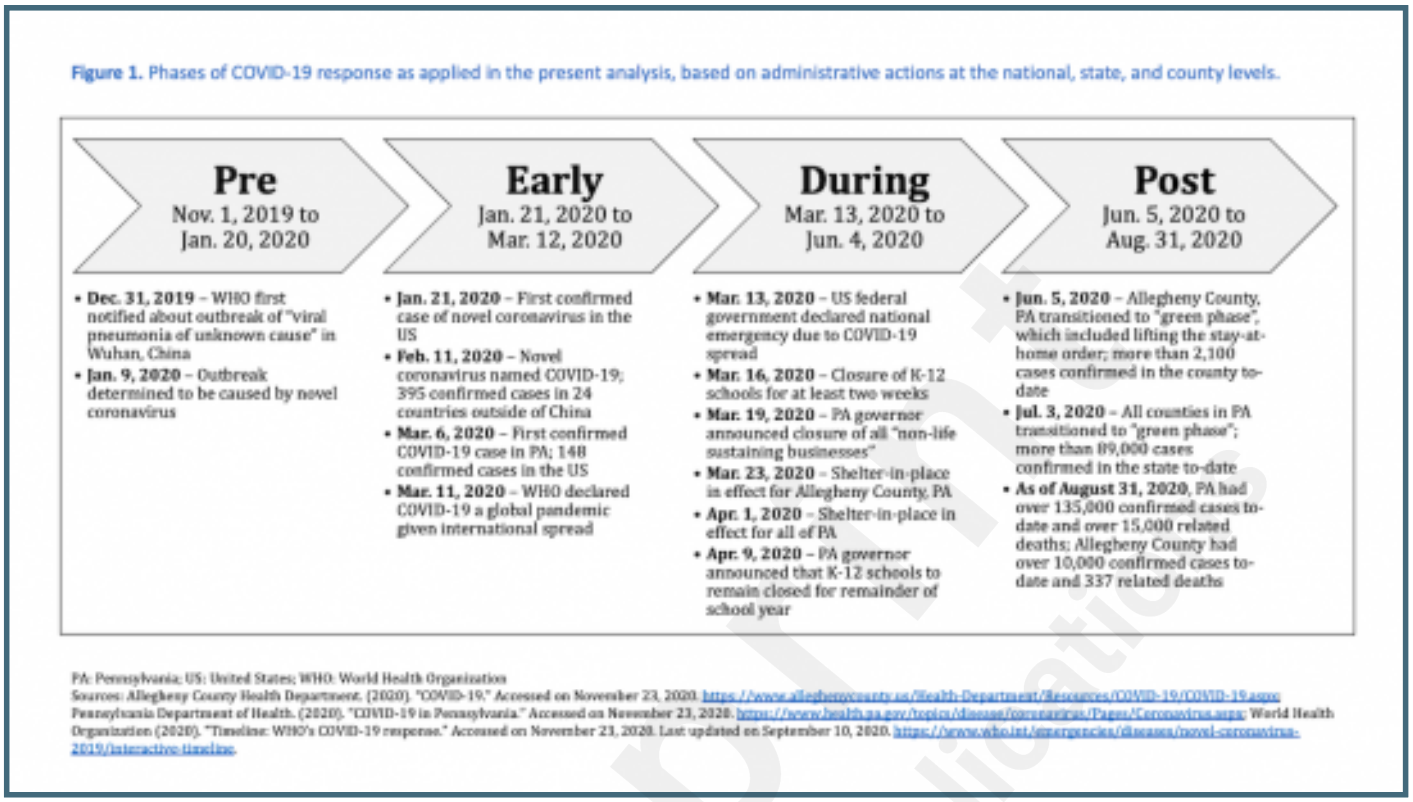
Supplementary Files

Figures

Phases of COVID-19 response as applied in the present analysis, based on administrative actions at the national, state, and county levels.



Mean Level of Stress for Each Phase by Race, Adjusted for marriage, education level, employment, and income level.

Figure 2. Mean Level of Stress for Each Phase by Race, Adjusted for marriage, education level, employment, and income level.