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Rates of self-reported postpartum depressive symptoms in the United States before and after the start of the COVID-19 pandemic

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ABSTRACT

Background: This study aimed to determine the relationship between the start of the COVID-19 pandemic and changes in postpartum depressive symptoms (PDS) in individuals in the United States. Further analyses explored how these changes related to state-level measures of pandemic severity, economic hardship, and social isolation.
Methods: Data were collected from users of the Flo mobile health application who completed a survey about their mood within 90 days of giving birth. Analyses assessed changes in national and state-level self-reported PDS from a pre-pandemic period (N = 159,478) to a pandemic period (N = 118,622). Linear regression determined which state-level pandemic severity or economic factors were associated with changes in PDS.
Results: National rates of PDS increased from 6.5% (pre-pandemic) to 6.9% (pandemic). There was a significant increase in PDS over the course of the pandemic timeframe. Linear regressions revealed a negative association between percent change in PDS across states and COVID-19 deaths per 100 K residents as well as 2020 women's unemployment rate. There was no association between change in PDS and COVID-19 cases per 100 K residents, percent job loss, percent change in women's unemployment rate, or percentage of population staying at home.
Conclusions: There was a national increase in PDS that worsened over the course of a year following the start of the COVID-19 pandemic. States with a greater increase in PDS tended to show overall fewer deaths from COVID-19 and lower women's unemployment rates. Further work is needed to identify what individual-level factors may be driving these differences.

1. Introduction

Perinatal psychiatric symptoms are highly prevalent and present a major public health problem around the world (Vesga-López et al., 2008). It is estimated that approximately 10–20% of individuals experience depressive symptoms within a year of their pregnancy (Ko et al., 2017). Maternal depression and depressive symptoms are not only unfavorable outcomes for mothers, but also have long-term effects on the health and development of children (Deave et al., 2008; Goodman et al., 2011; Madigan et al., 2018). The coronavirus (COVID-19) pandemic, which has disrupted the lives of millions of people around the world, presents as an additional stressor for this particularly vulnerable population. The start of the COVID-19 pandemic led to several ramifications in a short timeframe: deaths, hospitalizations, stay at home orders, economic hardship, and uncertainty about the future. Understanding how the pandemic has affected depressive symptoms in postpartum individuals is crucial for developing strategies to support this population.

Emerging evidence suggests that the pandemic has led to an increase in depressive symptoms in the general population (Ettman et al., 2020; Salari et al., 2020; Vindegaard and Benros, 2020), as well as an increase in psychiatric symptoms in pregnant and postpartum individuals (Berthelot et al., 2020; Hessami et al., 2020; Lebel et al., 2020; Liu et al., 2021; Perzow et al., 2021; Zanardo et al., 2020). This work suggests that risk factors for higher absolute levels of depression and anxiety symptoms in pregnant and postpartum individuals during the pandemic include having a history of a psychiatric diagnosis (Berthelot et al., 2020; Liu et al., 2021) and higher levels of COVID-19 related worries and adversity (Lebel et al., 2020; Liu et al., 2021; Perzow et al., 2021). Some work suggests that low socioeconomic status is a risk factor for more psychiatric distress during the pandemic (Berthelot et al., 2020), while other longitudinal work has suggested that it is not related to

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changes in distress (Perzow et al., 2021). Other work, however, suggests that the pandemic coincided with a *decrease* in postpartum depressive symptoms in certain populations that could have been due to increased time spent at home with social supports (Pariente et al., 2020). Previous studies present data from limited sample sizes, and it remains unclear what factors are associated with *changes* in depressive symptoms in postpartum women during the pandemic (as opposed to risk factors for absolute levels of symptoms). In addition to the disease burden associated with the pandemic, economic factors and social isolation could also be key contributing factors, as they have previously been shown to impact PDS (Guintivano et al., 2018). Given the variable impact that the pandemic has had on different geographic regions, changes in postpartum depressive symptoms could have varied based on region, which previous work has not yet examined.

This study aims to further characterize how rates of depressive symptoms in postpartum individuals in the United States changed following the start of the COVID-19 pandemic, and what factors may be associated with that change. We compared self-reported mood ratings from a time period prior to the pandemic to a time period after the start of the pandemic in a large national sample of postpartum individuals using a popular mobile health application. Further analyses examined the association between changes in PDS and state-level measures of pandemic severity, economic hardship, and social isolation.

2. Methods

2.1. Data source

The data in this study were obtained using the Flo Health (Flo Health, n.d.) mobile application (app). The Flo app is a women's health app with over 165 million users worldwide that provides tools that allow users to track their menstrual cycle or to track mood or physical symptoms during pregnancy and postpartum. The app is available for download on both Google Play and the Apple App Store and thus the study included both Android and iOS phone owners.

2.2. Data acquisition

Data in this study included individuals in the United States who completed the Flo app's "post-pregnancy" survey between January 2018 and March 2021. This survey was sent to users within 90 days of their reported delivery date. The data were deidentified and sent in aggregate to the Johns Hopkins research team, with responses stratified by state. The geolocation of the user was estimated based on their IP address. Participants in the study agreed to the use of their deidentified and aggregate data for research purposes. Procedures were approved by the Johns Hopkins Institutional Review Board.

2.3. Measurement of Postpartum Depressive Symptoms (PDS)

The post-pregnancy survey included a question that asked, "How would you characterize your emotional state after giving birth?" The answer choices were one of the following: 1) I don't want to answer (no response); 2) I am in high spirits (high spirits); 3) I can characterize my condition as emotionally stable (emotionally stable); 4) I am experiencing mood swings (mood swings); 5) I am experiencing anxiety, irritability, dissatisfaction (anxiety); 6) I feel sad, hopeless, helpless, useless, I am scared for my child, I have feelings of guilt and shame (hopelessness); 7) No emotions at all, I feel disconnected, emotionally exhausted with no energy to take proper care of my child (anhedonia). We defined postpartum depressive symptoms (PDS) as answering either 5, 6 or 7 on the survey as these answers were most clearly negative.

2.4. State-level variables

We obtained data on the following state-level variables related to the disease and economic burden of the COVID-19 pandemic: COVID-19 cases per 100,000 residents between March 1, 2020, and March 31, 2021 (Centers for Disease Control and Prevention, 2020), COVID-19 deaths per 100,000 residents between March 1, 2020 and March 31, 2021 (Centers for Disease Control and Prevention, 2020), percent job loss between February 2020 and April 2021 (Michael Ettlinger and Jordan Hensley, 2020), women's unemployment rate in 2020 (U.S. Bureau of Labor Statistics, 2021), percent change in women's unemployment from 2019 to 2020 (U.S. Bureau of Labor Statistics, 2021), percentage of population staying at home between March 1, 2020 and March 31, 2021 (U.S. Department of Transportation, 2020).

2.5. Statistical analyses

To assess whether the national rate of PDS changed after the start of the COVID-19 pandemic, we calculated the overall rate of PDS in a "pre-pandemic" timeframe of January 2018 to February 2020 and a "pandemic" timeframe of March 2020 to March 2021 in the United States. The change in PDS was defined as the percent change of the rate of PDS from the pre-pandemic to the pandemic period. We also defined the change categorically: no change (absolute percent change between 0% and 5%), increase (percent change >5%), and decrease (percent change < - 5%). These analyses were repeated at the state-level and at the regional level using the Health and Human Services (HHS) definition of United States regions (U.S. Department of Health and Human Services, 2006).

To investigate how PDS rates changed over the course of the first year of the pandemic, the nationwide rate of PDS was calculated at four timepoints: Q1: March 2020–May 2020, Q2: June 2020–August 2020, Q3: September 2020–November 2020, Q4: December 2020–March 2021. To assess how pandemic trends compared to trends prior to the pandemic, the nationwide rate of PDS was calculated at the following pre-pandemic timepoints: January 2018–December 2018, January 2019–March 2019, April 2019–June 2019, July 2019–September 2019, October 2019–December 2019, January 2020–February 2020. Data from 2018 was combined into one timepoint due to a sparse sample size in the first nine months of that year. A Jonckheere-Terpstra test for ordered alternatives was utilized to test for change in PDS over time within each period.

Linear regression models investigated the association between individual state-level factors and the change in PDS. All variables were standardized prior to regression modeling to account for differences in scale (e.g. COVID-19 cases per 100 K residents vs. percent of population staying at home). Individual predictors that were significant at the level of $\alpha = 0.05$ were retained and entered into a multivariate regression model. To further evaluate the driving factors contributing to the associations, individual predictors that were significant were also assessed to see whether they were associated with pre-pandemic levels of PDS.

Exploratory analyses investigated the individual items of the post-pregnancy survey. Pearson's Chi Squared test was used to compare the distribution of answers before and after the start of the pandemic at the national level. Additionally, linear regression analyses were repeated to test for associations between each individual item measuring PDS (anxiety, hopelessness, and anhedonia) and state-level factors which were found to be significantly associated with overall changes in PDS.

Analyses were conducted using R statistical software (R Core Team, 2019) and statistical significance was evaluated at a level of 0.05.

3. Results

The "pre-pandemic" period (January 2018–February 2020) included a sample of 159,478 participants and the "pandemic" period (March 2020–March 2021) included a sample of 118,622 participants.

In the total sample, 6.5% of respondents endorsed PDS in the pre-pandemic period compared to 6.9% in the pandemic period, representing a 6.31% increase in the PDS rate following the start of the

pandemic. At the state level, 36 states showed an increase in PDS, 7 states showed a decrease, and 8 states showed no change. State-level percent change in PDS is depicted in Fig. 1 and Supplemental Table 1. States with a higher pre-pandemic PDS rate tended to show a smaller percent change in PDS from the pre-pandemic to the pandemic period ($\beta = -0.512$, SE = 0.123, $F(1, 49) = 17.36$, $p < .001$). At the regional level, six of the ten regions saw a percent increase in PDS >5% and four regions saw no change (Table 1).

There was a significant change in PDS over the course of the pandemic timeframe ($T_{JT} = 6$, $z = 2.04$, $p = .042$), suggesting an increase in PDS as the pandemic has continued. In contrast, analyses within the pre-pandemic period revealed no significant change in PDS ($T_{JT} = 11$, $z = 1.32$, $p = .189$). Fig. 2 depicts the rates of PDS at different timepoints throughout the pre-pandemic and pandemic period.

Simple linear regression models revealed a negative association between COVID-19 deaths per 100 K residents and percent change in PDS across states, such that states with a larger pandemic death toll showed a smaller increase in PDS compared to states with a smaller pandemic death toll ($\beta = -0.396$, SE = 0.131, $F(1, 49) = 9.12$, $p = .004$, Fig. 3A). In contrast, there was a positive association between COVID-19 deaths per 100 K residents and pre-pandemic PDS, such that states with greater pre-pandemic PDS suffered a greater death toll compared to states with a smaller pre-pandemic PDS rate ($\beta = 0.304$, SE = 0.136, $F(1, 49) = 5.00$, $p = .029$). However, when controlling for pre-pandemic rates using a multivariate model ($F(2, 48) = 11.57$, $p < .001$), the negative association between change in PDS and COVID-19 deaths per 100 K residents remained significant ($\beta = -0.265$, SE = 0.125, $p = .038$).

Additionally, there was a negative association between unemployment in women (2020 estimated rate) and percent change in PDS, such that states with a larger unemployment rate in women showed a smaller increase in PDS compared to states with a smaller unemployment rate in women ($\beta = -0.405$, SE = 0.131, $F(1, 49) = 9.61$, $p = .003$, Fig. 3B). In contrast, there was no relation between unemployment in women in 2020 and pre-pandemic PDS rates ($p = .96$). There was no significant association between change in PDS and COVID-19 cases per 100,000 residents, percent job loss between February 2020 and April 2021, percent change in women's unemployment rate from 2019 to 2020, or percentage of population staying at home ($p > .07$). In the multivariate model ($F(2, 48) = 7.87$, $p = .001$), states' change in PDS was significantly predicted by COVID-19 deaths per 100 K residents ($\beta = -0.302$, SE = 0.131, $p = .026$) and 2020 unemployment rate in women ($\beta = -0.315$, SE = 0.131, $p = .021$).

At the item-level, there was a significant change in the distribution of responses from the pre-pandemic to the pandemic time period (X^2 (6, N = 278,100) = 188.58 $p < .001$; Supplemental Table 2). This was characterized as a relative increase in items 1 (no response), 4 (mood swings), 5 (anxiety), a relative decrease in item 7 (anhedonia), and no change in items 2 (high spirits), 3 (emotionally stable), and 6 (hopelessness). Exploratory state-level analyses found that COVID-19 deaths per 100 K residents was negatively associated with anxiety ($\beta = -0.324$, SE = 0.135, $F(1, 49) = 5.76$, $p = .020$) and hopelessness ($\beta = -0.403$, SE = 0.131, $F(1, 49) = 9.47$, $p = .003$) but not anhedonia ($p = .617$). In contrast, 2020 unemployment in women was negatively associated with anhedonia ($\beta = -0.532$, SE = 0.121, $F(1, 49) = 19.33$, $p < .001$) but not anxiety and hopelessness ($p > .158$).

4. Discussion

Our study revealed a national increase in PDS following the start of the pandemic which steadily worsened over the course of a year. In contrast, there was no significant change in PDS during the pre-pandemic period. At the state level, states with *fewer* deaths per capita from COVID-19 showed a *greater* increase in PDS, driven by changes in anxiety and hopelessness. Additionally, states with *lower* unemployment rates in women for 2020 showed a *greater* increase in PDS, driven by changes in anhedonia. There was no association between change in PDS and COVID-19 cases per capita, percent job loss between February 2020 and April 2021, percent change in women's unemployment from 2019 to 2020, or percentage of population staying at home. Together, these data suggest that though there was an overall increase in PDS, the states that were less heavily impacted by the pandemic (i.e. had a smaller death toll per capita and a lower women's unemployment rate) showed a greater increase in PDS compared to states that were more heavily impacted by the pandemic.

There are several possible explanations for this pattern of state-level findings. One possibility is that in states where there was a higher death toll or women's unemployment rate, families spent more time together and the new mothers had greater access to their support systems. Previous work has suggested that increased social support is protective against PDS in the pandemic (Lebel et al., 2020; Pariente et al., 2020; Terada et al., 2021). In states less impacted by the pandemic in these ways, new mothers may have faced the stresses of the pandemic without as much access to their support system. Another possible explanation is that participants in states which showed decreases in PDS are different demographically from the sample in the states which showed increases in PDS. For example, respondents from different states could have differed in their distribution of demographic factors such as race, age, and socioeconomic status, which we were unable to control for given the

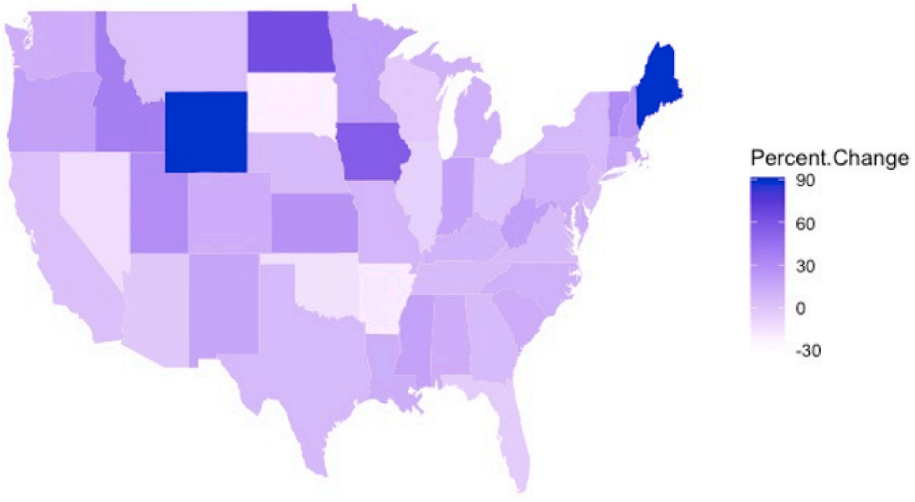

Fig. 1. Heat map depicting percent change in rates of self-reported Postpartum Depressive Symptoms (PDS) by state from a pre-pandemic (January 2018–February 2020) to a pandemic (March 2020–March 2021) time period.

Table 1
Rates of self-reported Postpartum Depressive Symptoms (PDS) by United States Health and Human Services region in pre-pandemic (January 2018–February 2020) and pandemic (March 2020–March 2021) time periods.

Region	Name	Total Responses Pre-Pandemic	Total Responses Pandemic	PDS Pre-Pandemic	PDS Pandemic	PDS Rate Pre-Pandemic	PDS Rate Pandemic	Percent Change
1	Northeast (Boston)	6732	375	4214	276	5.57%	6.55%	17.58%
2	NY + NJ (NYC)	12307	674	9206	533	5.48%	5.79%	5.72%
3	Mid-Atlantic (DC)	14873	967	11688	816	6.50%	6.98%	7.38%
4	Southeast (Atlanta)	33877	2338	24059	1737	6.90%	7.22%	4.61%
5	Midwest (Chicago)	24699	1599	17039	1150	6.47%	6.75%	4.25%
6	South Central (Dallas)	23836	1749	18170	1382	7.34%	7.61%	3.66%
7	North Central (Kansas City)	6514	407	4782	360	6.25%	7.53%	20.49%
8	Rocky Mountain (Denver)	6035	357	4619	329	5.92%	7.12%	20.41%
9	Southwest (San Francisco)	24267	1540	20245	1299	6.35%	6.42%	1.11%
10	Pacific Northwest (Seattle)	6338	366	4600	315	5.77%	6.85%	18.58%

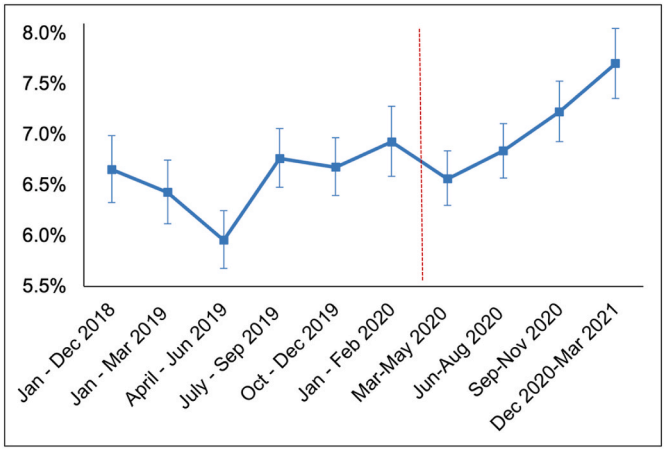

Fig. 2. Rates of self-reported Postpartum Depressive Symptoms (PDS) over the course of pre-pandemic and pandemic time periods. *Note*: error bars represent binomial distribution 95% confidence intervals.

data at hand. Since there was a negative association between baseline PDS rates and percent change in PDS from the pre-pandemic to pandemic period, it was possible that the negative association between change in PDS and death toll per capita and women's unemployment rate could have been driven by positive associations between these state-level measures and baseline levels of PDS. However, our results do not support this explanation. We found no association between women's unemployment and pre-pandemic PDS, and though there was a significant association between pre-pandemic PDS and death toll per capita during the pandemic, the association between the death toll per capita and change in PDS remained significant after controlling for pre-pandemic PDS rates.

At the item-level, the relative proportion of symptoms of anxiety increased, anhedonia decreased, and hopelessness stayed relatively stable from pre-pandemic to pandemic time-periods. This suggests that increases in anxiety could potentially have been the driving force for the overall increase in PDS. Previous work supports the finding that anxiety increased in this population after the start of the pandemic (Hessami et al., 2020; Perzow et al., 2021). Because participants in our study were tasked to choose the response that *best* characterized their mood and were therefore only able to select one item, this pattern of results could suggest that in the context of the additional stress induced by the pandemic, anxiety was the most accurate description of participant's self-perceived mood (as compared to anhedonia, for example).

There are several limitations to our study. First, rates of PDS were approximated using self-reported responses to one survey question. Because of this, we can only describe the rate of depressive symptoms, not the rate of postpartum depression diagnoses. Additionally, the data collected were de-identified and sent in aggregate, so we are unable to control for any individual-level variables that could have contributed to the increase in PDS. Because the data were sent in aggregate, we were also not able to explore time from delivery date to survey response as a factor in our analyses, and therefore cannot differentiate between those responding a few days following delivery vs. 60–90 days following delivery. Furthermore, there could be a bias in who has access to and chooses to use the Flo app, and it is possible that these findings may not generalize to the broader population.

The primary strength of our study is that it includes a large sample size from participants across the nation. Additionally, having data

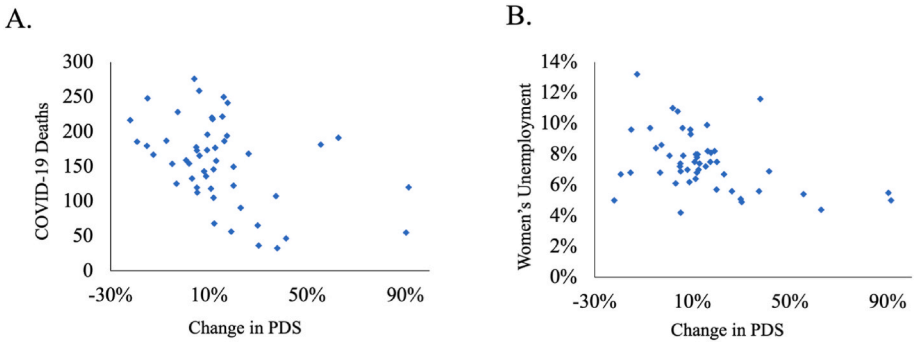

Fig. 3. State-level associations between percent change in self-reported Postpartum Depressive Symptoms (PDS) and (A) COVID-19 deaths per 100,000 residents between March 1, 2020 and March 31, 2021, (B) women's unemployment rate in 2020.

available from a pre-pandemic period allowed us to quantify the *change* in PDS over time and how this change relates to state-level measures of pandemic severity.

5. Conclusion

In summary, our data reveal that while there was a national increase in PDS that worsened over the course of a year following the start of the COVID-19 pandemic, states with a greater increase in PDS tended to show overall less deaths from COVID-19 and lower unemployment rates in women. These data potentially suggest that the quarantine setting was in some ways protective against PDS in certain populations. Further research is needed to identify which individual-level factors may be driving these differences.

Author statement

Dr. Payne conceived of the study, directed the statistical analysis and assisted in writing the manuscript. Mira Bajaj conducted the statistical analyses and wrote the initial draft of the manuscript. Drs. Zhaunova and Salimgaraev assisted in conceiving the study and pulled the data for analysis. All authors participated in editing the manuscript and approved the final draft. The authors wish to thank Flo Health for their collaboration on this project. This research did not receive any funding.

Declaration of competing interest

Mira Bajaj – None; Drs. Salimgaraev and Zhaunova are salaried employees of Flo Health. Dr. Payne has served as a consultant for SAGE Therapeutics, Brii Biosciences, and Pure Tech Health. Dr. Payne has received an honorarium from Karuna Therapeutics. Dr. Payne owns a patent entitled "Epigenetic Biomarkers of Postpartum Depression," has received research support from NIMH for topics related to postpartum depression, has received honoraria for CMEtoGO and UPtoDate articles related to postpartum depression, royalties from a book she edited entitled "Biomarkers of Postpartum Psychiatric Disorders." She also serves on two DSMB's overseeing clinical trials for treating and screening for postpartum depression, is the president-elect for two societies focused on perinatal mental health, is on the editorial board for Archives of Women's Mental Health and sits on several committees focus on perinatal mental health.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2022.04.011.

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