Variations in health behaviors among pregnant women during the COVID-19 pandemic

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ABSTRACT

Purpose: To examine changes in lifestyle behaviors early in the COVID-19 pandemic among pregnant women.

Materials and methods: A cross-sectional internet-based survey was completed by 706 pregnant women (mean age 29.6 years ± 3.2) residing in the United States in May 2020 to assess self-reported changes in diet, physical activity, and sleep during the COVID-19 pandemic. Logistic regression analyses examined whether sociodemographic, clinical, and pandemic-related characteristics were associated with health behavior changes.

Results: Approximately 17% of women reported their diets worsened during the COVID-19 pandemic, 42% reported improvements, and 41% reported no change. For physical activity, 22% reported they stopped being active, 2% reported they became active, and 76% reported no change. Nearly one-third of participants reported getting less sleep. The factors consistently associated with adverse lifestyle changes (worse diet, stopped being active, and reduced sleep) were experiences of pregnancy complications, loss of income due to COVID-19, and changes in social connections due to COVID-19.

Conclusions: A substantial proportion of pregnant women reported adverse lifestyle changes during the COVID-19 pandemic. Interventions during the pandemic to optimize health behaviors in pregnant women, especially among those with pregnancy complications, should address economic disadvantages and social support.

Introduction

The emergence of Severe Acute Respiratory Syndrome-Coronvirus-2 (SARS-CoV-2) and the disease it causes, COVID-19, has profoundly influenced our daily lives and represents a major public health challenge. In the absence of a vaccine, a primary recommended strategy to prevent the spread of COVID-19 is to avoid close contact with others by steps such as social distancing and isolation (Mahtani et al., 2020). However, these prevention strategies may have an adverse effect on diet, physical activity, and sleep patterns (Ammar et al., 2020; Forte et al., 2020; Lin et al., 2020; Mattioli et al., 2020; Scarmozzino and Visioli, 2020; Sidor and Rzymski, 2020; Tison et al., 2020). For example, in an online cross-sectional survey of adults in Poland, Sidor et al., found that nearly 45% of participants reported eating more during quarantine, and over 50% reported snacking between meals more frequently (Sidor and Rzymski, 2020). Further, there was a 27.3% decrease in mean steps (-1,432 steps/day) reported within 30 days of the pandemic declaration among nearly half a million individuals globally (Tison et al., 2020).

A study including 5,461 individuals in China found that self-reported sleep quality and insomnia were adversely altered during the pandemic compared to before the pandemic (Lin et al., 2020).

High levels of perceived stress, such as those produced by social distancing and isolation during a pandemic, are associated with poorer diet, physical inactivity, and reduced sleep duration and quality (Elran-Barak and Mozeikov, 2020; Kim and Dimsdale, 2007; Ng and Jeffery, 2003). Pregnant women may be more vulnerable to adverse lifestyle changes in response to the COVID-19 pandemic, due to the accumulation of multiple sources of perceived stress (Rashidi Fakari and Simbar, 2020). This is particularly concerning as adverse lifestyle changes during pregnancy have important implications for the health of both the mother and child. Research is needed to understand the potential influence of the COVID-19 pandemic on changes in health-related behaviors during pregnancy. Further, advancing understanding of the correlates of health behavior change among pregnant women will identify high-risk groups to target for intervention during this pandemic and future pandemics. Thus, the objectives of this study were to assess

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in pregnant women during the COVID-19 pandemic: (1) self-reported changes in diet, physical activity, and sleep and (2) whether sociodemographic, clinical, and other pandemic-related characteristics were associated with health behavior changes.

Methods

Study Design

Data for this project were from the COVID-19: Health in Pregnancy and Postpartum (CHIPP) Study. The purpose of the larger study was to understand how social distancing practices due to the COVID-19 pandemic affect pregnancy and postpartum health behaviors, health outcomes, and access to obstetric care among women residing in the United States. Pregnant women were recruited through nation-wide social media sites including Facebook and Twitter by targeting pregnancy-related groups or hash-tags as well as community health programs (e.g., Healthy Start) to complete a 30-minute online survey. Groups were specifically targeted that included a large proportion of minority or low-income pregnant women to ensure a diverse sample. Inclusion criteria were: at least 8-week pregnant at survey administration (May 6-8, 2020), aged 18-44 years, and residing in the United States. Women who answered 90% of the survey questions and provided a valid email or mailing address received a $10 Amazon gift card. The study protocol was approved by the "X" Institutional Review Board and all women provided written consent before completing the survey.

We received 881 survey responses. After excluding those who were ineligible (n=46), duplicate responses from the same IP address (n=32), and those with <90% of questions completed (n=50), 755 survey responses remained. An additional nine women were excluded because their expected due dates were before the survey completion date, resulting in a final study population of 746 women. Due to missing data in health behaviors and covariates, the model sample sizes varied from 653 to 706 women.

Health Behavior Change

Change in diet quality was assessed by asking "Since COVID-19, how has your diet changed?" Response options were: (1) Getting much better, (2) Getting a bit better, (3) The same (did not change), (4) Getting a bit worse, and (5) Getting much worse. Before answering this question, participants read a statement describing a healthy diet consistent with the Dietary Guidelines for Americans that has been previously used in pregnancy research (Whitaker et al., 2020; Whitaker et al., 2016). For analysis, change in diet quality was converted to three groups: better (getting much better and getting a bit better), same, and worse diet (getting a bit worse and getting much worse).

Change in leisure-time physical activity was assessed using a question from the 2019 Behavioral Risk Factor Surveillance System (BRFSS) (Centers for Disease Control and Prevention (CDC), 2019): "Other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise during each of the following times?" Response options were yes, no, don't know, or refused. Responses assessing participation in leisure-time physical activity before and after March 2020 (when the COVID-19 pandemic spread to the United States) were used to construct a new variable representing change in physical activity before and during the COVID-19 pandemic. Categories included: (1) never active (reported no leisure time activity before or after March 2020), (2) stopped being active (reported leisure time activity before March 2020 but not after), (3) became active (reported leisure time activity after March 2020 but not before) and (4) remained active (reported leisure time activity before and after March 2020). Participants reporting that they started being active were excluded from multivariable analysis due to the small sample size (n=14).

Change in sleep was assessed by asking "Do you feel that you are getting less sleep because of the COVID-19 pandemic?" Response options were yes or no.

Correlates of Health Behavior Change

Several items from the Pandemic Stress Index (Harkness et al., 2020) and a survey examining social connections (Ensminger et al., 2009) were included in the survey and adapted for pregnancy to estimate stress related to the COVID-19 pandemic. Relevant items hypothesized to have an association with health behaviors were included in the present study (Elran-Barak and Mozeikov, 2020; Gollwitzer et al., 2020; Pampel et al., 2010; Umberson and Montez, 2010), including: (1) income loss due to COVID-19, (2) social distancing practices, and (3) connections with neighbors/community, friends, family, and partner. Loss of income was assessed by asking "Did you lose your source of income because of COVID-19?" Response options were yes or no. For social distancing practices, women were asked whether they practiced social distancing, which was defined as reducing physical contact with other people in social, work or school settings by avoiding large groups and staying 3-6 feet away from other people. The response options were: "Yes, very strictly", "Yes, but not strictly", and "No, I am not." Women who responded "Yes, very strictly" were coded as strict social distancing vs. others, which included those who did not strictly practice social distancing or did not practice social distancing. Social connections were assessed by asking women to rate how their connections with neighbors/community, friends, family, partner, and child(ren) changed since COVID-19 (separate questions for each group). Response options were substantially closer, somewhat closer, stay the same, somewhat farther, substantially farther, or not applicable. All five social connection variables were included in an exploratory factor analysis with Varimax rotation to identify distinct individual-level social connection scores (Fabrigar et al., 1999). We omitted social connection changes with one's children due to substantial missingness from the final factor analysis (approximately 43% of the study sample was nulliparous). We identified factor retention by a scree plot, and only one factor was retained to indicate a composite level of changes in connections with social ties. Higher scores indicate stronger overall social connections with neighbors/community, friends, family, and/or partner.

Sociodemographic and clinical factors were also examined as potential correlates of health behavior change during COVID-19. These included age, race/ethnicity, marital status, educational attainment, annual household income, employment status, urban or rural residence determined using the Rural-Urban Commuting Area Codes 3.0 version, parity, trimester, pre-pregnancy BMI category, and any pregnancy complications. Trimester (first, second, or third) was determined by calculating gestational age using each woman's estimated due date. Women who did not know their estimated due date were classified as "Don't know" for trimester. Pre-pregnancy BMI was calculated using self-reported pre-pregnancy height and weight and categorized as underweight, normal weight, overweight, and obese. Pregnancy complications included high blood pressure, HELLP, gestational diabetes, anemia, placenta previa, depression/anxiety, or other diagnoses.

Statistical Analyses

Bivariate analyses examined whether there were differences in participant characteristics by self-reported change in diet, physical activity, and sleep during the COVID-19 pandemic, using Chi-square tests of independence or one-way analysis of variance. Multinomial logistic regression examined if participant characteristics were associated with change in diet during the COVID-19 pandemic, categorized as worse, same (referent group), or better. Similarly, multinomial logistic regression was used to examine which participant characteristics were associated with change in physical activity, categorized as never active, stopped being active, or remained active (referent group). Logistic regression was used

to examine associations of participant characteristics with sleep change. All models included age, race/ethnicity, educational attainment, annual family income, employment status, urban or rural residence, parity, trimester, pre-pregnancy BMI category, any pregnancy complications, as well as pandemic-related characteristics including lost source of income, strictly social distancing, and social connections. Marital status was not included in multivariable analyses due to the limited variability in responses (98.4% married). In sensitivity analyses we also adjusted for United States Census Region (Northeast, Midwest, South, and West); study findings were unchanged.

Findings

Participant characteristics of those included and excluded from analyses can be found in **Supplemental Table 1**. Compared to those who were included, participants excluded were more likely to be non-Hispanic White and had lower levels of education, a higher annual family income, were working part-time or were unemployed, had an underweight pre-pregnancy BMI, and were less likely to report being physically active.

The included study population had representation from all 50 U.S. states, with an average age of 29.6 ± 3.2 years (Table 1). Participants were predominantly Non-Hispanic Black, married, highly educated, employed, residing in urban areas, and had a normal pre-pregnancy BMI. Approximately 27% reported losing their source of income due to COVID-19, 62% reported strictly social distancing at the time of survey completion, and the average social connection score was -0.008 ± 0.689. More specifically, 27.6%, 67.1%, 25.9% and 30.1% of women reported their connections with family, friends, neighbors, and their partner were further apart due to COVID-19, respectively. Approximately 17% of women reported their diets worsened during the COVID-19 pandemic, 41% reported no changes and 42% reported improvements in diet. For physical activity, 20% reported never being active, 22% reported they stopped being active, 2% reported they became active, and 56% reported that they remained active. Approximately 28% of participants reported getting less sleep during the COVID-19 pandemic compared to before.

Table 2 shows bivariate and multinomial logistic regression analyses examining participant characteristics with diet change. In bivariate analysis, all participant characteristics were associated with change in diet, with the exception of urban/rural residence and pre-pregnancy BMI. A one-year increase in age was associated with higher odds of reporting worsening diet during the COVID-19 pandemic (aOR 1.13, 95% CI: 1.04, 1.22). Compared to non-Hispanic Black women, all other race/ethnicity groups had higher odds of reporting worsening diet (aOR range 3.19, 4.64, 95% CI range: 1.12, 12.42). Women with annual family income of $50,000 or more had lower odds of reporting improvements in diet than women with less than $50,000 annual family income (aOR: 0.22, 95% CI range: 0.12, 0.41). Compared to those with full-time employment, women employed part-time or out of work/homemakers also had lower odds of reporting improvements in diet (aOR range 0.27, 0.42, 95% CI range: 0.13, 0.83). Women who reported any pregnancy complications had higher odds of reporting changes in diet (worse aOR: 2.65, 95% CI: 1.41, 4.98 and better aOR: 2.92, 95% CI: 1.63, 5.24). Women who lost their source of income had higher odds of reporting worsening diet (aOR 3.08, 95% CI: 1.59, 5.98). Women with closer social connections had higher odds of reporting improvements in diet (aOR: 1.41, 95% CI: 1.05, 1.89).

All participant characteristics were associated with change in physical activity with the exception of urban/rural residence and pre-pregnancy BMI in bivariate analysis (Table 3). In multivariable analysis with those reporting remaining active serving as the referent group, a one-year increase in age was associated with higher odds of reporting never being active or stopping physical activity participation during the COVID-19 pandemic (aOR range 1.16, 1.20, 95% CI range: 1.05, 1.32). Compared to non-Hispanic Black women, Hispanic women had higher

Table 1
Participant characteristics (N=706).

Participant Characteristics	Mean ± SD or n(%)
Age, years	29.6 ± 3.2
Race/ethnicity	
Hispanic	65 (9.2)
Non-Hispanic White	272 (38.5)
Non-Hispanic Black	315 (44.6)
Non-Hispanic Others	54 (7.7)
Marital status	
Married	695 (98.4)
Not married	11 (1.6)
Education attainment	
Less than bachelor degree	206 (29.2)
Bachelor or graduate degree	500 (70.8)
Annual family income	
<$50,000	362 (51.3)
$50,000-$80,000	145 (20.5)
>$80,000	199 (28.2)
Employment status	
Full time employed	164 (65.3)
Part-time employed	124 (17.6)
Out of work/homemaker	21 (17.1)
Urban or rural residence[a]	
Urban	617 (87.4)
Rural	89 (12.6)
United States Census Region[b]	
Northeast	97 (13.7)
Midwest	153 (21.7)
South	274 (38.8)
West	182 (25.8)
Parity	
Nulliparous	303 (42.9)
Multiparous	403 (57.1)
Trimester	
1st Trimester	245 (34.7)
2nd Trimester	275 (39.0)
3rd Trimester	100 (14.2)
Don't know	86 (12.2)
Pre-pregnancy BMI	
Underweight	61 (8.6)
Normal weight	573 (81.2)
Overweight/Obese	72 (10.2)
Pregnancy complications[b]	134 (19.0)
COVID-19 Measures	
Lost source of income	189 (26.8)
Strictly social distancing	435 (61.6)
Social connection score[c]	-0.008 ± 0.689
Diet change	
Worse	117 (16.6)
Same	293 (41.5)
Better	296 (41.9)
Physical activity change, n=667	
Never active	133 (19.9)
Stopped being active	149 (22.3)
Became active	14 (2.1)
Remained active	371 (55.6)
Sleep change, n=705	
Less sleep	194 (27.5)
Same/more sleep	511 (72.5)

[a] Determined using Rural-Urban Commuting Area Codes 3.0 version.

[b] Pregnancy complications included high blood pressure, HELLP, gestational diabetes, anemia, placenta previa, depression/anxiety, or other diagnoses.

[c] Higher social connection score indicates closer connections to family, friends, partner, and neighbors.

odds of stopping physical activity participation (aOR: 2.93, 95% CI: 1.08, 7.91). Women in the highest income category also had higher odds of stopping physical activity participation (aOR: 5.62, 95% CI: 2.68, 11.80), and women who were part-time or unemployed had a lower odds of stopping physical activity participation (aOR: 0.40, 95% CI range: 0.16, 0.99). Multiparous women also had lower odds of stopping phys-

Table 2
Associations of participant characteristics with change in diet during COVID-19 (N=706).

Participant Characteristics	Diet Change				Adjusted OR[b]	
	Mean ± SD or n(%)					
	Worse	Same	Better	p-value[a]	Worse vs. Same	Better vs. Same
Age, years	30.9 ± 4.0	29.4 ± 3.0	29.4 ± 2.8	**<0.001**	**1.13 (1.04, 1.22)**	0.98 (0.91, 1.04)
Race/ethnicity				**<0.001**		
Non-Hispanic Black	18 (15.4)	110 (37.5)	187 (63.2)		1.00 (Ref)	1.00 (Ref)
Non-Hispanic White	71 (60.7)	132 (45.1)	69 (23.3)		**3.82 (1.75, 8.35)**	0.83 (0.47, 1.44)
Hispanic	10 (8.6)	25 (8.5)	30 (10.1)		**3.19 (1.12, 9.09)**	1.15 (0.53, 2.49)
Non-Hispanic Others	18 (15.4)	26 (8.9)	10 (3.4)		**4.64 (1.74, 12.42)**	0.49 (0.19, 1.22)
Education attainment				**<0.001**		
Less than bachelor degree	51 (43.6)	104 (35.5)	51 (17.2)		1.00 (Ref)	1.00 (Ref)
Bachelor or graduate degree	66 (56.4)	189 (64.5)	245 (82.8)		1.06 (0.61, 1.83)	1.42 (0.86, 2.35)
Annual family income				**<0.001**		
<$50,000	48 (41.0)	102 (34.8)	212 (71.6)		1.00 (Ref)	1.00 (Ref)
$50,000-$80,000	35 (29.9)	82 (28.0)	28 (9.5)		0.52 (0.27, 1.02)	**0.22 (0.12, 0.41)**
>$80,000	34 (29.1)	109 (37.2)	56 (18.9)		0.55 (0.27, 1.11)	**0.22 (0.12, 0.39)**
Employment status				**<0.001**		
Full time employed	40 (34.2)	182 (62.1)	239 (80.7)		1.00 (Ref)	1.00 (Ref)
Part-time employed	34 (29.1)	56 (19.1)	34 (11.5)		1.38 (0.66, 2.86)	**0.42 (0.22, 0.83)**
Out of work/homemaker	43 (36.8)	55 (18.8)	23 (7.8)		1.46 (0.69, 3.07)	**0.27 (0.13, 0.58)**
Urban or rural residence[c]				0.142		
Urban	97 (82.9)	254 (86.7)	266 (89.9)		1.00 (Ref)	1.00 (Ref)
Rural	20 (17.1)	39 (13.3)	30 (10.1)		1.33 (0.66, 2.70)	0.60 (0.34, 1.07)
Parity				**<0.001**		
Nulliparous	57 (48.7)	163 (55.6)	83 (28.0)		1.00 (Ref)	1.00 (Ref)
Multiparous	60 (51.3)	130 (44.4)	213 (72.0)		1.18 (0.65, 2.13)	1.21 (0.74, 1.99)
Trimester				**<0.001**		
1st Trimester	23 (19.7)	83 (28.3)	139 (47.0)		1.00 (Ref)	1.00 (Ref)
2nd Trimester	39 (33.3)	138 (47.1)	98 (33.1)		0.62 (0.31, 1.27)	0.99 (0.62, 1.57)
3rd Trimester	34 (29.1)	34 (11.6)	32 (10.8)		1.85 (0.83, 4.10)	1.18 (0.57, 2.43)
Don't know	21 (18.0)	38 (13.0)	27 (9.1)		0.65 (0.26, 1.65)	0.97 (0.43, 2.22
Pre-pregnancy BMI				0.627		
Underweight	11 (9.4)	27 (9.2)	23 (7.8)		0.65 (0.28, 1.51)	1.48 (0.73, 2.99)
Normal weight	90 (76.9)	237 (80.9)	246 (83.1)		1.00 (Ref)	1.00 (Ref)
Overweight/Obese	16 (13.7)	29 (9.9)	27 (9.1)		0.58 (0.26, 1.30)	1.38 (0.67, 2.83)
Any pregnancy complications[d]	46 (39.3)	35 (12.0)	53 (17.9)	**<0.001**	**2.65 (1.41, 4.98)**	**2.92 (1.63, 5.24)**
COVID-19 measures						
Lost source of income	71 (60.7)	64 (21.8)	54 (18.2)	**<0.001**	**3.08 (1.59, 5.98)**	1.38 (0.71, 2.67)
Strictly social distancing	73 (62.4)	196 (66.9)	166 (56.1)	**0.026**	1.06 (0.61, 1.84)	1.33 (0.89, 1.99)
Social connection score[e]	-0.137 ± 0.711	-0.084 ± 0.734	0.118 ± 0.613	**<0.001**	0.88 (0.63, 1.23)	**1.41 (1.05, 1.89)**

[a] P-value testing for differences by diet change group using chi-square tests or one-way analysis of variance, as appropriate.

[b] Models adjusted for all listed participant characteristics.

[c] Determined using Rural-Urban Commuting Area Codes 3.0 version.

[d] Pregnancy complications included high blood pressure, HELLP, gestational diabetes, anemia, placenta previa, depression/anxiety, or other diagnoses.

[e] Higher social connection score indicates closer connections to family, friends, partner, and neighbors.

ical activity participation compared to nulliparous women (aOR: 0.07, 95% CI: 0.04, 0.14). Compared to those in the first trimester, those who were in the second or third trimester, or who did not know their due date were also more likely to report stopping physical activity participation (aOR range: 3.35, 35.88, 95% CI range: 1.35, 124.01). Women with an overweight or obese pre-pregnancy BMI had a higher odds of never being active (aOR: 4.54, 95% CI: 1.91, 10.82), and those reporting any pregnancy complications were more likely to report never being active (aOR: 6.77, 95% CI: 3.23, 14.20) or stopping physical activity participation (aOR: 5.77, 95% CI: 2.73, 12.17). Similarly, women who reported losing their source of income had higher odds of never being active (aOR: 3.27, 95% CI: 1.52, 7.00) or stopping physical activity participation (aOR: 2.93, 95% CI: 1.33, 6.45). Stronger social connections was associated with higher odds of stopping physical activity participation (aOR: 1.56, 95% CI: 1.08, 2.25).

All participant characteristics were associated with change in sleep in bivariate analysis with the exception of parity and strictly social distancing (Table 4). In multivariable analysis, a one-year increase in age was associated with higher odds of less sleep (aOR: 1.21, 95% CI: 1.12, 1.30). Compared to non-Hispanic Blacks, non-Hispanic Whites and non-Hispanic Others had higher odds of less sleep (aOR: 2.52, 95% CI: 1.34,

4.75 and aOR: 4.09, 95% CI: 1.74, 9.62, respectively). Higher income levels were also associated with a greater odds of less sleep, but this association was only significant for the middle income group (aOR: 2.03, 95% CI: 1.11, 3.71). Higher odds of less sleep was observed among women working part-time (compared to full time employment; aOR: 1.89, 95% CI: 1.01, 3.52), who resided in rural areas (compared to urban areas; aOR: 2.33, 95% CI: 1.24, 4.37), who didn't know their due date (compared to first trimester; aOR: 4.15, 95% CI: 1.86, 9.24), who reported any pregnancy complications (aOR: 3.68, 95% CI: 2.14, 6.32), and who lost their source of income (aOR: 2.74, 95% CI: 1.49, 5.02). Stronger social connections was associated with lower odds of reporting less sleep (aOR: 0.62, 95% CI: 0.45, 0.84).

Discussion

In this sample of more than 700 pregnant women, we sought to better understand self-reported changes in diet, physical activity, and sleep during the COVID-19 pandemic and to determine whether sociodemographic, clinical, and other pandemic-related characteristics were associated with health behavior change. The majority of participants reported no changes or improvements in lifestyle behaviors during the COVID-19 pandemic. More specifically, over 80% of participants re-

Table 3

Associations of participant characteristics with change in physical activity during COVID-19 (N=653)[a].

Participant Characteristics	Physical Activity Change			p-value[b]	Adjusted OR[c]	
	Mean ± SD or n(%)				Never Active vs. Remained Active	Stopped Being Active vs. Remained Active
	Never Active	Stopped Being Active	Remained Active			
Age, years	30.1 ± 3.3	29.8 ± 2.9	29.3 ± 3.2	**<0.001**	**1.20 (1.10, 1.32)**	**1.16 (1.05, 1.27)**
Race/ethnicity				**<0.001**		
Non-Hispanic Black	26 (19.6)	46 (30.9)	234 (63.1)		1.00 (Ref)	1.00 (Ref)
Non-Hispanic White	79 (59.4)	68 (45.6)	99 (26.7)		1.12 (0.54, 2.36)	0.91 (0.46, 1.81)
Hispanic	17 (12.8)	26 (17.5)	16 (14.3)		2.71 (0.95, 7.73)	**2.93 (1.08, 7.91)**
Non-Hispanic Others	11 (8.3)	9 (6.0)	22 (5.9)		0.75 (0.23, 2.50)	0.50 (0.16, 1.56)
Education attainment				**<0.001**		
Less than bachelor degree	68 (51.1)	38 (25.5)	75 (20.2)		1.00 (Ref)	1.00 (Ref)
Bachelor or graduate degree	65 (48.9)	111 (74.5)	296 (79.8)		0.58 (0.31, 1.06)	1.50 (0.81, 2.80)
Annual family income				**<0.001**		
<$50,000	57 (42.9)	40 (26.9)	251 (67.7)		1.00 (Ref)	1.00 (Ref)
$50,000-$80,000	48 (36.1)	28 (18.8)	54 (14.6)		1.76 (0.89, 3.50)	2.13(0.99, 4.59)
>$80,000	28 (21.1)	81 (54.4)	66		0.88 (0.40, 1.92)	**5.62 (2.68, 11.80)**
Employment status				**<0.001**		
Full time employed	55 (41.4)	95 (63.8)	286 (77.1)		1.00 (Ref)	1.00 (Ref)
Part-time employed	44 (33.1)	30 (20.1)	34 (9.2)		0.46 (0.20, 1.06)	**0.40 (0.17, 0.92)**
Out of work/homemaker	34 (25.6)	24 (16.1)	51 (13.8)		0.48 (0.20, 1.14)	**0.40 (0.16, 0.99)**
Urban or rural residence[c]				0.098		
Urban	109 (82.0)	130 (87.3)	331 (89.2)		1.00 (Ref)	1.00 (Ref)
Rural	24 (18.1)	19 (12.8)	40 (10.8)		0.77 (0.33, 1.79)	0.71 (0.30, 1.68)
Parity				**<0.001**		
Nulliparous	84 (63.2)	109 (73.2)	83 (22.4)		1.00 (Ref)	1.00 (Ref)
Multiparous	49 (36.8)	40 (26.9)	288 (77.6)		**0.10 (0.05, 0.19)**	**0.07 (0.04, 0.14)**
Trimester				**<0.001**		
1st Trimester	27 (20.3)	14 (9.4)	195 (52.6)		1.00 (Ref)	1.00 (Ref)
2nd Trimester	51 (38.4)	76 (51.0)	125 (33.7)		1.43 (0.72, 2.83)	**4.79 (2.27, 10.14)**
3rd Trimester	20 (15.0)	29 (19.5)	43 (11.6)		0.53 (0.22, 1.30)	**3.35 (1.35, 8.33)**
Don't know	35 (26.3)	30 (20.1)	8 (2.2)		**10.78 (3.48, 33.40)**	**35.88 (10.38, 124.01)**
Pre-pregnancy BMI				0.627		
Underweight	12 (9.0)	12 (8.1)	23 (6.2)		1.09 (0.45, 2.64)	0.80 (0.34, 1.92)
Normal weight	89 (65.4)	123 (82.6)	328 (88.4)		1.00 (Ref)	1.00 (Ref)
Overweight/Obese	34 (25.6)	14 (9.4)	20 (5.4)		**4.54 (1.91, 10.82)**	0.45 (0.17, 1.22)
Any pregnancy complications[d]	49 (36.8)	33 (22.2)	30 (8.1)	**<0.001**	**6.77 (3.23, 14.20)**	**5.77 (2.73, 12.17)**
COVID-19 measures						
Lost source of income	73 (54.9)	49 (32.9)	49 (13.2)	**<0.001**	**3.27 (1.52, 7.00)**	**2.93 (1.33, 6.45)**
Strictly social distancing	91 (68.4)	99 (66.4)	215 (58.0)	**0.026**	1.29 (0.69, 2.40)	0.99 (0.54, 1.80)
Social connection score[e]	-0.045 ± 0.882	0.052 ± 0.779	-0.046 ± 0.555	**<0.001**	1.13 (0.79, 1.62)	**1.56 (1.08, 2.25)**

[a] N=14 women who were categorized as 'became active' were excluded from analyses due to the small sample size.

[b] P-value testing for differences by diet change group using chi-square tests or one-way analysis of variance, as appropriate.

[c] Models adjusted for all listed participant characteristics.

[d] Pregnancy complications included high blood pressure, HELLP, gestational diabetes, anemia, placenta previa, depression/anxiety, or other diagnoses.

[e] Higher social connection score indicates closer connections to family, friends, partner, and neighbors.

ported their diet stayed the same or improved, approximately 75% reported no change in physical activity, and over 70% reported no change or increases in sleep duration. However, between 17%-28% of participants reported adverse changes in one or more of these lifestyle behaviors. Participant characteristics most consistently associated with adverse changes in behaviors during the COVID-19 pandemic were diagnosis of pregnancy complications, loss of source of income, and changes in social connections as a result of the pandemic.

Research examining lifestyle behavior change in pregnancy during the COVID-19 pandemic is just emerging. Biviá-Roig and colleagues recently published results from an online cross-sectional survey of 90 pregnant women in Spain that examined adherence to the Mediterranean diet and physical activity before and during the COVID-19 pandemic (Bivia-Roig et al., 2020). The results showed no differences in eating patterns but significant declines in physical activity levels. In contrast, in the current study we observed more variability in dietary changes, with nearly 60% reporting their diets changed during COVID-19 (17% worsened, 42% improved). The notable differences in study findings could be due to many factors, such as the smaller sample size in the study of Biviá-Roig et al., different study locations, and important differences in the methods of diet and physical activity assessment.

For an example of the measurement differences, in the study of Biviá-Roig et al. variation was likely masked when comparing average diet quality before and during the COVID-19 pandemic rather than specifically asking about changes in diet. Other studies examining dietary changes during COVID-19 in non-pregnant populations have generally reported mixed results (Ammar et al., 2020; Di Renzo et al., 2020; Elran-Barak and Mozeikov, 2020; Scarmozzino and Visioli, 2020; Sidor and Rzymski, 2020).

We observed more consistency in physical activity patterns before and during the COVID-19 pandemic, with less than 25% reporting changes in activity patterns. However, the changes reported could be due to pregnancy stage rather than the pandemic, given that we assessed activity patterns prior to March, 2020 (when COVID-19 spread to the U.S.), and after March, 2020. Thus a woman who transitioned from the 2nd to 3rd trimester when the pandemic reached the U.S. may have stopped her physical activity participation due to the discomfort of her pregnancy progression, rather than in response to the COVID-19 pandemic. Physical activity participation tends to decline in the third trimester of pregnancy compared to other trimesters (Borodulin et al., 2009; Evenson and Wen, 2010, 2011) and we also found women in the 2nd and 3rd trimesters were more likely to report stopping physical ac-

Table 4
Participant characteristics by change in sleep during COVID-19 (N=705).

Participant Characteristics	Sleep Change		p-value[a]	Adjusted OR[b]
	Mean ± SD or n(%)			
	Less Sleep	Same or More Sleep		Less Sleep vs. Same or More Sleep
Age, years	31.0 ± 3.5	29.1 ± 2.9	**<0.001**	**1.21 (1.12, 1.30)**
Race/ethnicity			**<0.001**	
Non-Hispanic Black	31 (16.0)	283 (55.4)		1.00 (Ref)
Non-Hispanic White	108 (55.7)	164 (32.1)		**2.52 (1.34, 4.75)**
Hispanic	24 (12.4)	41 (8.0)		2.10 (0.91, 4.81)
Non-Hispanic Others	31 (16.0)	23 (4.5)		**4.09 (1.74, 9.62)**
Education attainment			**<0.001**	
Less than bachelor degree	82 (42.3)	123 (24.1)		1.00 (Ref)
Bachelor or graduate degree	112 (57.7)	388 (75.9)		0.89 (0.55, 1.46)
Annual family income			**<0.001**	
<$50,000	69 (35.6)	293 (57.3)		1.00 (Ref)
$50,000-$80,000	64 (33.0)	81 (15.9)		**2.03 (1.11, 3.71)**
>$80,000	61 (31.4)	137 (26.8)		1.66 (0.90, 3.04)
Employment status			**<0.001**	
Full time employed	89 (45.9)	371 (72.6)		1.00 (Ref)
Part-time employed	67 (34.5)	57 (11.2)		**1.89 (1.01, 3.52)**
Out of work/homemaker	38 (19.6)	83 (16.2)		0.57 (0.29, 1.15)
Residence in urban areas[c]			**<0.001**	
Urban	156 (80.4)	459 (90.0)		1.00 (Ref)
Rural	38 (19.6)	51 (10.0)		**2.33 (1.24, 4.37)**
Parity			0.130	
Nulliparous	92 (47.4)	210 (41.1)		1.00 (Ref)
Multiparous	102 (52.6)	301 (58.9)		1.13 (0.68, 1.89)
Trimester			**<0.001**	
1st Trimester	26 (13.4)	218 (42.7)		1.00 (Ref)
2nd Trimester	69 (35.6)	206 (40.3)		1.15 (0.63, 2.11)
3rd Trimester	45 (23.2)	55 (10.8)		1.85 (0.90, 3.80)
Don't know	54 (27.8)	32 (6.3)		**4.15 (1.86, 9.24)**
Pre-pregnancy BMI			**<0.001**	
Underweight	30 (15.5)	31 (6.1)		1.91 (0.98, 3.74)
Normal weight	135 (69.6)	437 (85.5)		1.00 (Ref)
Overweight/Obese	29 (15.0)	43 (8.4)		0.63 (0.31, 1.27)
Any pregnancy complications[d]	79 (40.7)	54 (10.6)	**<0.001**	**3.68 (2.14, 6.32)**
COVID-19 measures				
Lost source of income	97 (50.0)	91 (17.8)	**<0.001**	**2.74 (1.49, 5.02)**
Strictly social distancing	127 (65.5)	307 (60.1)	0.189	1.34 (0.82, 2.17)
Social connection score[d]	-0.139 ± 1.471	0.042 ± 0.607	**0.002**	**0.62 (0.45, 0.84)**

[a] P-value testing for differences by diet change group using chi-square tests or one way analysis of variance, as appropriate.

[b] Models adjusted for all listed participant characteristics.

[c] Pregnancy complications included high blood pressure, HELLP, gestational diabetes, anemia, placenta previa, depression/anxiety, or other diagnoses.

[d] Higher social connection score indicates closer connections to family, friends, partner, and neighbors.

tivity participation compared to women in the first trimester. These decreases in activity may have been due to social distancing and isolation policies as reported in non-pregnant populations (Ammar et al., 2020; Elran-Barak and Mozeikov, 2020; Tison et al., 2020), but we are unable to disentangle these two potential drivers of physical activity reduction.

Our results indicating that approximately one-third of participants were getting less sleep during the COVID-19 pandemic is consistent with others reports of increased sleep problems during the pandemic in non-pregnant populations (Huang and Zhao, 2020; Lin et al., 2020). Poor sleep is a common complaint during pregnancy, with nearly 80% of pregnant women self-reporting poor sleep across pregnancy trimesters (Mindell et al., 2015), compared to 35-52% of non-pregnant women (Asghari et al., 2012; Beaudreau et al., 2012; Ko et al., 2010). Thus it is concerning that pandemic related stressors may lead to additional adverse changes in sleep in pregnant women.

We identified many sociodemographic, clinical, and pandemic-related characteristics associated with increased odds of adverse changes in diet, physical activity, and/or sleep during pregnancy during the COVID-19 pandemic, including older age, higher income, not being employed full-time, rural residence, nulliparity, later timing in pregnancy (2nd or 3rd trimester), presence of pregnancy complications,

and loss of income due to COVID-19. Race/ethnicity and changes in social connections due to COVID-19 were also associated with adverse changes, but findings differed across lifestyle behaviors. The factors most consistently associated with adverse changes during the pandemic across all three lifestyle behaviors were presence of pregnancy complications, loss of income, and alterations in social connections. Women with pregnancy complications, such as gestational diabetes, may perceive themselves as being more susceptible to adverse outcomes if they were to contract COVID-19, similar to those with comparable chronic health conditions (e.g., type 2 diabetes) (Williamson et al., 2020). Thus, heightened perceived susceptibility to COVID-19 may lead to stress-induced sleep problems as well as modifications in behaviors to mitigate risk of exposure, such as foregoing grocery shopping or not going out to exercise. However, the possibility of reverse causation remains, where adverse changes in lifestyle behaviors due to the COVID-19 pandemic may contribute to pregnancy complications. It is not surprising that loss of income due to the COVID-19 pandemic was associated with adverse changes in lifestyle behaviors during pregnancy given that low socioeconomic status and perceived stress are both independently associated with less optimal health behaviors (Elran-Barak and Mozeikov, 2020; Kim and Dimsdale, 2007; Ng and Jeffery, 2003; Pampel et al., 2010).

Consistent with our hypothesis, we found that women with closer social connections during COVID-19 had lower odds of worsening diet and less sleep. This finding is consistent with other research demonstrating that the association between social support or social interactions and health outcomes may be mediated by health behavior change (Emmons et al., 2007; Uchino, 2006). Unexpectedly, we found that high social connections scores were associated with a greater odds of stopping physical activity participation. This finding should be further explored in future studies using more robust assessments of physical activity.

There were several seemingly counterintuitive findings in our analyses. For example, women with higher incomes had lower odds of reporting improvements in diet during the COVID-19 pandemic. It is important to note that women with higher incomes were not more likely to report worsening diet, rather, their diets remained consistent. This could indicate that financial stability allowed them to continue their typical dietary patterns early in the pandemic, or alternately, we may be observing a ceiling effect, where high income women were more likely to eat a healthy diet before the pandemic and thus had less room for improvement. We also found that women in the highest income category were more likely to stop physical activity participation. It is possible that women with higher incomes were more likely to exercise in a gym setting, and when the pandemic began all gyms were closed which led to a reduction in physical activity. Alternately, women with higher incomes who were employed may have had the option to transition to remote work, thus leading to reductions in transportation activity. Also, women who reported part-time employment were more likely to report less sleep during the pandemic compared to women who reported full-time employment. One explanation for this finding is that women working part-time may have greater concerns about losing their job compared to those working full time. Perceived instability in employment may then contribute to sleep disruptions. Notably, these explanations are speculative, and there is the possibility of residual confounding or confounding due to unmeasured variables.

Key strengths of this study include the large nationwide sample of pregnant women and assessment of behavior change during the COVID-19 pandemic, which remains largely unexplored in pregnant populations, yet has important health implications for mother and baby. However, multiple study limitations must be noted. First, we relied on self-reported assessments of diet, physical activity, and sleep, which could be prone recall or social desirability bias. Second, our assessment of physical activity did not specifically ask about change in activity due to COVID-19, but rather assessed physical activity before and after COVID-19 spread to the United States. Thus, as described earlier, it is possible that physical activity change could be due to women progressing in their pregnancy, rather than as a result of the pandemic. Third, women were only asked whether they were getting less sleep, without additional assessment of other relevant dimensions of sleep such as sleep quality or timing. Further, while our sleep assessment specifically assessed changes in sleep duration *due to COVID-19*, it is impossible to fully tease out whether disruptions in sleep were due solely to the pandemic or because of their pregnancy status. Fourth, the timing of the COVID-19 pandemic did vary by population density and geographical location. While we did adjust for rural vs. urban residence and additional adjustment for U.S. census region did not alter study findings in sensitivity analysis, it is possible that lifestyle behaviors would be more affected in areas with more COVID-19 cases. Finally, our study sample was not representative of the general U.S. population, as clearly indicated by the high levels of education (70% college graduates) and BMI status (81% normal weight), thus limiting generalizability of study findings.

In conclusion, this study provides evidence that lifestyle behaviors in pregnancy have been adversely altered during the COVID-19 pandemic. The factors most consistently associated with adverse changes across lifestyle behaviors were pregnancy complications, loss of income, and change in social connections. These results can be used when developing behavioral and policy-level interventions to optimize health behaviors among women pregnant during the COVID-19 pandemic and future pandemics to improve health outcomes for mother and baby.

References

Ammar, A., Brach, M., Trabelsi, K., Chtourou, H., Boukhris, O., Masmoudi, L., Bouaziz, B., Bentlage, E., How, D., Ahmed, M., Muller, P., Muller, N., Aloui, A., Hammouda, O., Paineiras-Domingos, L.L., Braakman-Jansen, A., Wrede, C., Bastoni, S., Pernambuco, C.S., Mataruna, L., Taheri, M., Irandoust, K., Khacharem, A., Bragazzi, N.L., Chamari, K., Glenn, J.M., Bott, N.T., Gargouri, F., Chaari, L., Batatia, H., Ali, G.M., Abdelkarim, O., Jarraya, M., Abed, K.E., Souissi, N., Van Gemert-Pijnen, L., Riemann, B.L., Riemann, L., Moalla, W., Gomez-Raja, J., Epstein, M., Sanderman, R., Schulz, S.V., Jerg, A., Al-Horani, R., Mansi, T., Jmail, M., Barbosa, F., Ferreira-Santos, F., Simunic, B., Pisot, R., Gaggioli, A., Bailey, S.J., Steinacker, J.M., Driss, T., Hoekelmann, A., 2020. Effects of COVID-19 Home Confinement on Eating Behaviour and Physical Activity: Results of the ECLB-COVID19 International Online Survey. Nutrients 12 (6). doi:10.3390/nu12061583.

Asghari, A., Farhadi, M., Kamrava, S.K., Ghalehbaghi, B., Nojomi, M., 2012. Subjective sleep quality in urban population. Arch Iran Med 15 (2), 95–98 012152/AIM.0010.

Beaudreau, S.A., Spira, A.P., Stewart, A., Kezirian, E.J., Lui, L.Y., Ensrud, K., Redline, S., Ancoli-Israel, S., Stone, K.L., Study of Osteoporotic, F., 2012. Validation of the Pittsburgh Sleep Quality Index and the Epworth Sleepiness Scale in older black and white women. Sleep Med 13 (1), 36–42. 10.1016/j.sleep.2011.04.005.

Bivia-Roig, G., La Rosa, V.L., Gomez-Tebar, M., Serrano-Raya, L., Amer-Cuenca, J.J., Caruso, S., Commodari, E., Barrasa-Shaw, A., Lison, J.F., 2020. Analysis of the Impact of the Confinement Resulting from COVID-19 on the Lifestyle and Psychological Wellbeing of Spanish Pregnant Women: An Internet-Based Cross-Sectional Survey. Int J Environ Res Public Health 17 (16). doi:10.3390/ijerph17165933.

Borodulin, K., Evenson, K.R., Herring, A.H., 2009. Physical activity patterns during pregnancy through postpartum. BMC Womens Health 9, 32. doi:10.1186/1472-6874-9-321472-6874-9-32, [pii].

Centers for Disease Control and Prevention (CDC), 2019. 2019 Behavioral Risk Factor Surveillance System Questionnaire. U.S. Department of Health and Human Services, Center for Disease Control and Prevention, Atlanta, Georgia.

Di Renzo, L., Gualtieri, P., Pivari, F., Soldati, L., Attina, A., Cinelli, G., Leggeri, C., Caparello, G., Barrea, L., Scerbo, F., Esposito, E., De Lorenzo, A., 2020. Eating habits and lifestyle changes during COVID-19 lockdown: an Italian survey. J Transl Med 18 (1), 229. doi:10.1186/s12967-020-02399-5.

Elran-Barak, R., Mozeikov, M., 2020. One Month into the Reinforcement of Social Distancing due to the COVID-19 Outbreak: Subjective Health, Health Behaviors, and Loneliness among People with Chronic Medical Conditions. Int J Environ Res Public Health 17 (15). doi:10.3390/ijerph17155403.

Emmons, K.M., Barbeau, E.M., Gutheil, C., Stryker, J.E., Stoddard, A.M., 2007. Social influences, social context, and health behaviors among working-class, multi-ethnic adults. Health Educ Behav 34 (2), 315–334. doi:10.1177/1090198106288011.

Ensminger, M.E., Juon, H.S., Lee, R., Lo, S.Y., 2009. Social Connections in the Inner City: Examination across the Life Course. Longit Life Course Stud 1 (1), 11–26. doi:10.14301/llcs.v1i1.27.

Evenson, K.R., Wen, F., 2010. National trends in self-reported physical activity and sedentary behaviors among pregnant women: NHANES 1999-2006. Prev Med 50 (3), 123–128. doi:10.1016/j.ypmed.2009.12.015, S0091-7435(09)00649-5 [pii].

Evenson, K.R., Wen, F., 2011. Prevalence and correlates of objectively measured physical activity and sedentary behavior among US pregnant women. Prev Med 53 (1-2), 39–43. doi:10.1016/j.ypmed.2011.04.014, S0091-7435(11)00167-8 [pii].

Fabrigar, L.R., Wegener, D.T., MacCallum, R.C., Strahan, E.J., 1999. Evaluating the use of exploratory factor analysis in psychological research. Psychological Methods 4 (3), 272.

Forte, G., Favieri, F., Tambelli, R., Casagrande, M., 2020. The Enemy Which Sealed the World: Effects of COVID-19 Diffusion on the Psychological State of the Italian Population. J Clin Med 9 (6). doi:10.3390/jcm9061802.

Gollwitzer, A., Martel, C., Marshall, J.A., Hohs, J.M., Bargh, J.A., 2020. Connecting Self-Reported Social Distancing to Real-World Behavior at the Individual and U.S. State Level [Preprint]. PsyArXiv doi:10.31234/osf.io/kvnwp, https://doi.org/10.31234/osf.io/kvnwp.

Harkness, A., Behar-Zusman, V., Safren, S.A., 2020. Understanding the Impact of COVID-19 on Latino Sexual Minority Men in a US HIV Hot Spot. AIDS Behav 24 (7), 2017–2023. doi:10.1007/s10461-020-02862-w.

Huang, Y., Zhao, N., 2020. Generalized anxiety disorder, depressive symptoms and sleep quality during COVID-19 outbreak in China: a web-based cross-sectional survey. Psychiatry Res 288, 112954. doi:10.1016/j.psychres.2020.112954.

Kim, E.J., Dimsdale, J.E., 2007. The effect of psychosocial stress on sleep: a review of polysomnographic evidence. Behav Sleep Med 5 (4), 256–278. doi:10.1080/15402000701557383.

Ko, S.H., Chang, S.C., Chen, C.H., 2010. A comparative study of sleep quality between pregnant and nonpregnant Taiwanese women. J Nurs Scholarsh 42 (1), 23–30. doi:10.1111/j.1547-5069.2009.01326.x.

Lin, L.Y., Wang, J., Ou-Yang, X.Y., Miao, Q., Chen, R., Liang, F.X., Zhang, Y.P., Tang, Q., Wang, T., 2020. The immediate impact of the 2019 novel coronavirus (COVID-19) outbreak on subjective sleep status. Sleep Med doi:10.1016/j.sleep.2020.05.018, 10.1016/j.sleep.2020.05.018.

Mahtani, K.R., Heneghan, C., Aronson, J.K., 2020. What is the evidence for social distancing during global pandemics? A rapid summary of current knowledge. University of Oxford.

Mattioli, A.V., Sciomer, S., Cocchi, C., Maffei, S., Gallina, S., 2020. Quarantine during COVID-19 outbreak: Changes in diet and physical activity increase the risk of cardiovascular disease. Nutr Metab Cardiovasc Dis doi:10.1016/j.numecd.2020.05.020, 10.1016/j.numecd.2020.05.020.

Mindell, J.A., Cook, R.A., Nikolovski, J., 2015. Sleep patterns and sleep disturbances across pregnancy. Sleep Med 16 (4), 483–488. doi:10.1016/j.sleep.2014.12.006.

Ng, D.M., Jeffery, R.W., 2003. Relationships between perceived stress and health behaviors in a sample of working adults. Health Psychol 22 (6), 638–642. doi:10.1037/0278-6133.22.6.638.

Pampel, F.C., Krueger, P.M., Denney, J.T., 2010. Socioeconomic Disparities in Health Behaviors. Annu Rev Sociol 36, 349–370. doi:10.1146/annurev.soc.012809.102529.

Rashidi Fakari, F., Simbar, M., 2020. Coronavirus Pandemic and Worries during Pregnancy; a Letter to Editor. Arch Acad Emerg Med 8 (1), e21. https://www.ncbi.nlm.nih.gov/pubmed/32185371.

Scarmozzino, F., Visioli, F., 2020. Covid-19 and the Subsequent Lockdown Modified Dietary Habits of Almost Half the Population in an Italian Sample. Foods 9 (5). doi:10.3390/foods9050675.

Sidor, A., Rzymski, P., 2020. Dietary Choices and Habits during COVID-19 Lockdown: Experience from Poland. Nutrients 12 (6). doi:10.3390/nu12061657.

Tison, G.H., Avram, R., Kuhar, P., Abreau, S., Marcus, G.M., Pletcher, M.J., Olgin, J.E., 2020. Worldwide Effect of COVID-19 on Physical Activity: A Descriptive Study. Ann Intern Med doi:10.7326/M20-2665, 10.7326/M20-2665.

Uchino, B.N., 2006. Social support and health: a review of physiological processes potentially underlying links to disease outcomes. J Behav Med 29 (4), 377–387. doi:10.1007/s10865-006-9056-5.

Umberson, D., Montez, J.K., 2010. Social relationships and health: a flashpoint for health policy. Journal of health and social behavior 51 (Suppl), S54–S66. doi:10.1177/0022146510383501.

Whitaker, K.M., Baruth, M., Schlaff, R.A., Connolly, C.P., Liu, J., Wilcox, S., 2020. Association of provider advice and gestational weight gain in twin pregnancies: a cross-sectional electronic survey. BMC Pregnancy Childbirth 20 (1), 417. doi:10.1186/s12884-020-03107-3.

Whitaker, K.M., Wilcox, S., Liu, J., Blair, S.N., Pate, R.R., 2016. Pregnant women's perceptions of weight gain, physical activity, and nutrition using Theory of Planned Behavior constructs. J Behav Med 39 (1), 41–54. doi:10.1007/s10865-015-9672-z.

Williamson, E.J., Walker, A.J., Bhaskaran, K., Bacon, S., Bates, C., Morton, C.E., Curtis, H.J., Mehrkar, A., Evans, D., Inglesby, P., Cockburn, J., McDonald, H.I., MacKenna, B., Tomlinson, L., Douglas, I.J., Rentsch, C.T., Mathur, R., Wong, A.Y.S., Grieve, R., Harrison, D., Forbes, H., Schultze, A., Croker, R., Parry, J., Hester, F., Harper, S., Perera, R., Evans, S.J.W., Smeeth, L., Goldacre, B., 2020. Factors associated with COVID-19-related death using OpenSAFELY. Nature 584 (7821), 430–436. doi:10.1038/s41586-020-2521-4.