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The Association Between Maternal Employment Precarity and Infant Low Birth Weight in a Nationally Representative Cohort of Women in the United States

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Abstract

Objectives: To investigate the association between maternal employment precarity and infant low birth weight (LBW), and to assess if this association differs by race/ethnicity.

Methods: Data were collected from 2,871 women enrolled in the National Longitudinal Survey of Youth 1979 and the National Longitudinal Survey of Youth Children Cohort. Employment Precarity was characterized as a composite measure of four employment characteristics (material rewards [score 0-2], working time arrangements [score 0-2], collective organization [score 0-1], and employability opportunities [score 0-1]) and was categorized into three groups labeled low (0-2), medium (3), and high (4-6). LBW was defined as weight less than 2500 grams at birth. Generalized linear models were fit to calculate risk ratios and 95% confidence intervals and adjusted for maternal age, race/ethnicity, educational attainment, nativity, pre-pregnancy body mass index, alcohol consumption, smoking during pregnancy and infant year of birth. We assessed effect modification by maternal race/ethnicity using a composite exposure variable.

Results: Women with high (RR: 1.49, 95%CI: 1.12-1.98) employment precarity had higher risk of a LBW delivery compared to women with low employment precarity. Compared to Non-Hispanic White women with low employment precarity, Non-Hispanic Black women (RR: 2.69; 95%CI: 1.73-4.17), Hispanic women (RR: 2.55; 95%CI: 1.55-4.19), and Non-Hispanic White women (RR: 1.46; 95%CI: 0.98-2.16) with high employment precarity had higher odds of LBW.

Conclusions: Findings of this study can be used to inform antenatal care and identify workplace policies to better support women who work during pregnancy.

Strengths and limitations of this study

- Our study is the first to use a multidimensional definition of employment precarity to study its association with low birthweight.
- Data was collected from a diverse cohort of women living in the United States, allowing us to examine the racial/ethnic differences in the association between employment precarity and low birthweight.
- This study could benefit from data on more dimensions of employment precarity and additional confounding variables.

What this paper adds?

1. What is already known about this subject?

   Traditional job stressors, such as job demand/control, have been associated with higher risk for adverse birth outcomes. In addition, atypical or non-permanent contracts, long working hours, and shift work have also been associated with preterm birth,

2. What this study adds?

   Our study is the first to use a multidimensional definition of employment precarity. We found that women with higher employment precarity had higher risk of low birth weight and this risk differed by race/ethnicity. Our findings can inform workplace policies to better support women during pregnancy.

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Competing Interests Statement

None declared

INTRODUCTION

Low birth weight (LBW) is associated with many chronic conditions in later life, including obesity, hypertension, and coronary heart diseases.[1,2] Infants born with LBW are at a higher risk of death in the first year of life and lower educational attainment and income earnings in adult life.[3-5] The prevalence of LBW deliveries in the United States has remained stagnant for more than two decades, with proportions recorded at about 7% in 1990 and 8% in 2016.[6] LBW disparities have also been recorded between racial/ethnic groups; in 2016 13.7% of infants born to Non-Hispanic Black women were LBW, compared to 7.0% and 7.3% of those born to Non-Hispanic White and Hispanic mothers, respectively.[6] While some exposures, such as income, maternal chronic conditions before and during pregnancy, and behavioral factors including smoking, have been established as risk factors of LBW, the stable prevalence over time and observed disparities in LBW suggest that further examination of potential risk factors should be considered.[7]

As of 2016, woman made up 46.8% of the total U.S. labor force--nearly 75% of which were of prime reproductive age (25-34 years) --and a growing number of studies have investigated maternal occupational exposures during pregnancy and birth outcomes.[8,9] Several studies have found associations with abnormal birth outcomes and work-related chemical exposures (e.g., solvents, toxic metals) and/or physical hazards (e.g., lifting, standing for long durations), although contradictory evidence exists.[10-14] A smaller number of studies have found associations between LBW and work-related psychosocial exposures, for example job strain as measured by the Job Demand-Control model.[15-17] These studies all focus on job content and working conditions, i.e., the nature of tasks and the physical and social environment in which work takes place; however, the relational and contractual aspects of employment have received less attention as potential risk factors for LBW. This is despite widespread concerns that the nature and structure of employment have dramatically changed in recent decades toward more

flexible, less secure employment arrangements.[18-21] Indeed, a growing body of research has identified the terms and conditions of the employee-employer relationship--which determine contract type, wages and benefits, hours, schedule, mobility opportunities, and workplace power dynamics--as important job-related determinants of health.[22,23]

Some indicators of employment conditions, when evaluated in isolation, have been associated with higher risk of LBW, including atypical or non-permanent contracts, long working hours, and shift work.[14,24] However, jobs are better conceived as a composite of several simultaneously occurring employment conditions, and it is the aggregation of these features that determine a worker's experience—such as whether a job is health-enhancing or deleterious. In other words, studies focused only on a single characteristic would fail to capture the complexity of contemporary employment arrangements. This has led to increased research attention to the multidimensional construct of precarious employment.[22] Employment precarity can be defined as an accumulation of poor employment conditions that produce an experience of unstable, insecure employment, with inadequate wages and benefits and lacking social protections.[25,26]

While employment precarity has been linked to several adverse health outcomes, no studies have applied this construct to the study of LBW.[22] Precarious employment can influence birth outcomes through several mechanisms. Most directly, precarious employment may cause maternal stress, such as through job insecurity, lack of control, or powerlessness.[26,27] Perinatal stress is thought to impact the hypothalamic pituitary adrenal (HPA) axis and affect fetal growth during pregnancy.[28-30] Furthermore, workers in precarious employment arrangements may have difficulty obtaining sufficient and stable income, as well as non-wage benefits.[26,31] This material deprivation could lead to impoverished living conditions or poor nutrition, which have been linked to LBW.[32,33]

The few studies evaluating individual employment conditions and birth outcomes were conducted outside of the United States, where different labor laws and social safety nets exist.[34,35] Further, few studies considered potential differences by racial/ethnic groups despite observed disparities in LBW.[36,37] This is especially relevant given evidence that precarious employment is socially distributed such that women, people of color, immigrants, younger workers, lower-skilled, and lower-educated workers are disproportionately represented.[38,39]

This study is the first to use a multidimensional definition of employment precarity to examine its association with infant LBW using a large, nationally representative cohort in the United States. We further examined differences in this association by race/ethnicity.

METHODS

The National Longitudinal Study of Youth (NLSY79), conducted by the United States Bureau of Labor Statistics, is a nationally representative longitudinal cohort (N=12,686) of individuals born between 1957 and 1964 and living in the United States at the start of the survey in 1979. Sampling weights accounted for oversampling of racial/ethnic minority groups and provided a nationally representative estimate of the United States population in 1979. Data collection began in 1979 and is ongoing. The NLSY79 Children cohort (N=11,521) began in 1986 and surveyed all children born to female respondents in the original cohort. The NLSY79 Children is linked to the original NLSY79 Cohort using the mother's ID to allow linkages across mother-infant pairs. At the start of data collection, 50% of the NLSY79 Cohort was female. As of 2014, the retention rate for the entire cohort is 71.0%.

This study included women enrolled in the NLSY79 Cohort who had a child enrolled in the NLSY79 Children cohort. Women were excluded if they did not have a first child born between 1978 to 2014 (N=1,353), did not list at least one job in the interview cycle during the birth year of

their first child (N=1,982), had an infant with a birth weight of 4500 grams or more (n=30), or had missing information on three or more work characteristics that were used to calculate the exposure (N=47). The final sample included in the analysis was 2,871 women (Figure 1). The last birth of a first-born child occurred in 2007 for women in the NLSY79, resulting in complete ascertainment of first births for this cohort. The Institutional Review Board at the University of Washington deemed this study to be exempt. Data used in this study are freely available on the NLSY website.

Patient and Public Involvement

Patients were not involved in the development of the research question or the implementation of the study.

Exposure

The primary exposure was maternal employment precarity measured in the interview cycle preceding infant birth. Precarity is conceptualized based on a framework used in a growing number of health studies in the European Union, which contains the following seven dimensions: (1) employment stability; (2) material rewards; (3) workers' rights and social protections; (4) working time arrangements; (5) training and employability opportunities; (6) collective organization; and (7) interpersonal power relations.[26,40] In this study we operationalized precarity using available indicators of employment conditions within four of the seven dimensions. *Material rewards* was scored as high, medium, or low based on two criteria: having employer-provided insurance (yes/no) and income in the last year adjusted for inflation to 1979 dollars (upper 50% of sample or lower 50% of sample). Those who had both employer-provided insurance and an income in the upper 50% of the sample were categorized as high (score of 0), those with either employer-provided insurance or an income in the upper 50% of the sample were considered medium (1), and those with no employer-provided insurance or an

income in the lower 50% of the sample were considered low (2). *Working time arrangements* was categorized as regular and irregular determined by participants' working hours per day (<=8 hours, >8 hours), and time of day working (day time, non-day time). Participants working <=8 hours a day and during the day were considered to have regular working times (0), those either working >8 hours or in a non-day time shift and those working both >8 hours and a non-day time shift were considered irregular (1-2). *Employability opportunities* was based on whether employers provided training or education to participants (0) or did not (1). *Collective organization* was determined by an indicator of union membership (or whether wages are set by a union if union membership was not asked in that survey year), with membership scored as 0 and no membership as 1. These four characteristics of employment are measured during the interview cycle prior to infant birth year and were summed to create an employment precarity composite measure ranging from 0 to 6, with higher scores reflecting greater employment precarity. Participants were further categorized into three groups based on their employment precarity composite score: low employment precarity (0-2), medium (3), and high (4-6). These cutoffs were determined based on the distribution of the employment precarity scores. During some survey years, questions pertaining to these work precarity dimensions were not asked. For those years, data from the previous survey cycle was used in place of the missing information.

Outcome

The outcome of interest was maternal-reported infant LBW defined as birth weight of less than 2500 grams (5 pounds, 8 ounces). An infant with birth weight of 2500-4500 grams was considered normal birth weight.

Other Variables: Several maternal covariates were included in the analyses: race/ethnicity (Non-Hispanic White, Non-Hispanic Black or Hispanic), age, educational attainment at time of pregnancy (less than high school, high school degree, or more than high school), nativity (born

in or outside of the United States), pre-pregnancy body mass index (BMI) calculated from self-reported height and weight, smoking during pregnancy (smoked at least once versus no smoking during pregnancy), alcohol consumption during pregnancy (any versus no alcohol consumption), as well as infant year of birth and infant sex (male or female). Race/ethnicity was considered a confounder and an effect modifier. All other covariates were included as confounders in the employment precarity—LBW relationship. Maternal age and pre-pregnancy BMI were treated as continuous variables.

Statistical Analysis

Descriptive statistics were used to compare sociodemographic and behavioral characteristics across employment precarity groups. To assess the relationship between employment precarity and infant LBW, a series of generalized linear models were fit to estimate risk ratios and their corresponding 95% confidence intervals. We evaluated precarious employment in three different ways. First, the association between each individual employment precarity component (material rewards, working time arrangements, employability opportunities, and collective organization), as well as variables used to create these components (income, insurance, shift time, and hours worked), and LBW were examined. Second, we evaluated the composite precarity measure specified as a categorical variable (low, medium, and high). Lastly, we evaluated a continuous specification of the composite measure. For all three analyses, we used a staged modelling approach, where Model 1 was an unadjusted generalized linear regression. Model 2 was adjusted for maternal age, maternal race/ethnicity, maternal educational attainment, maternal nativity, and infant year of birth. Model 3 was additionally adjusted for behavioral factors, including maternal pre-pregnancy BMI, and maternal smoking and alcohol use during pregnancy and was considered our primary model.

We examined effect modification by race/ethnicity using the approach recommended by VanderWeele and colleagues (2014) which created an employment precarity-race composite

variable that combines the effect modifier and the exposure.[41] The reference group was low employment precarity in Non-Hispanic White women. Risk ratios and corresponding 95% confidence intervals were calculated using fully adjusted generalized linear models to explore effect modification. Analyses were conducted using SAS 9.4 and statistical significance was determined using the $p<0.05$ cut-off.

RESULTS

Among study participants, 45% (N=1,305) had low employment precarity, 21% (N=607) had medium employment precarity, and 33% (N=959) had high employment precarity. High and medium employment precarity had a higher prevalence of younger and Non-Hispanic Black or Hispanic women compared to low employment precarity (Table 1). High and medium employment precarity also had a higher proportion of less than high school educated women and smoking during pregnancy. High employment precarity had a smaller proportion of women who consumed alcohol compared to women with low employment precarity. Mean age was higher for low employment precarity (26.0, SD: 5.5) and lower for medium and high precarity (24.5, SD: 4.9 and 21.7, SD: 3.8). Pre-pregnancy BMI was higher for low and medium employment precarity (24.0, SD: 4.6 and 23.5, SD: 4.6) compared to high employment precarity (23.5, SD: 4.6). Missingness for employment precarity variables was similar between outcome groups (Table 2). All precarity variables had missingness below 6% except for material rewards and insurance. Overall, 88% (N=2529) of participants delivered normal birthweight infants and 12% (N=342) delivered LBW infants.

Table 1. Selected Sociodemographic Characteristics of Study Participants from the NLSY79 [a] Cohort (1979-2007)

	Entire Sample (N=2871)		Low Employment Precarity (N=1305)		Medium Employment Precarity (N= 607)		High Employment Precarity (N=959)	
	N or	% or	N or	% or	N or	% or	N or	% or SD

	Mean	SD	Mean	SD	Mean	SD	Mean	
Age (years)	24.3	5.2	26.0	5.5	24.5	4.9	21.7	3.8
Missing	0	0	0	0	0	0	0	0
Pre-Pregnancy Body Mass Index (kg/m^2)[b]	23.8	5.4	24.0	4.6	23.9	7.6	23.5	4.6
Missing	94	3.3	51	3.9	15	2.5	28	2.9
Maternal Race/ Ethnicity								
Non-Hispanic Black	600	20.9	262	20.1	106	17.5	232	24.2
Hispanic	495	17.2	212	16.2	95	15.7	188	19.6
Non-Hispanic White	1776	61.9	831	63.7	406	66.9	539	56.2
Missing	0	0	0	0	0	0	0	0
Maternal Nativity								
In the United States	2682	93.4	1222	93.6	571	94.1	889	92.7
Outside of the United States	189	6.6	83	6.4	36	5.9	70	7.3
Missing	0	0	0	0	0	0	0	0
Maternal Educational Attainment								
Less than High School	479	16.7	144	11.0	78	12.9	257	26.8
High School	1231	42.9	503	38.5	272	44.8	456	47.6
More than High School	1161	40.4	658	50.4	257	42.3	246	25.7
Missing	0	0	0	0	0	0	0	0
Infant Sex								
Male	1420	49.5	670	51.3	294	48.4	456	47.6
Female	1451	50.5	635	48.7	313	51.6	503	52.5
Missing	0	0	0	0	0	0	0	0
Maternal Smoking								
Smoked at Least Once	811	28.3	317	24.3	174	28.7	320	33.4
Did Not Smoke	1916	66.7	913	70.0	409	67.4	594	61.9
Missing	144	5.0	75	5.8	24	4.0	45	4.7
Maternal Alcohol								
Consumed at Least Once	1336	46.5	633	48.5	300	49.2	403	42.0
Did Not Consume Alcohol	1392	48.5	598	45.8	282	46.5	512	53.4
Missing	143	5.0	74	5.7	25	4.1	44	4.6

[a] NLSY79: National Longitudinal Survey of Youth 1979
[b] Body Mass Index calculated using self-reported height and self-report weight

Table 2. Descriptive statistics of maternal employment precarity by percent of low and normal birth weight, NLSY79 [a] Cohort (1979-2007)

			Entire Sample (N=2871)		Low Birth Weight		Normal Birth Weight	
			N	%	N	%	N	%
Material Rewards		High	1102	38.4	129	37.7	973	38.5
		Medium	546	19.0	69	20.2	477	18.9
		Low	891	31.0	105	30.7	786	31.1
		Missing	332	11.6	39	11.4	293	11.6
	Income[b]	Upper 50%	1327	46.2	159	46.5	1168	46.2
		Lower 50%	1385	48.2	164	48.0	1221	48.3
		Missing	159	5.5	19	5.6	140	5.5
	Insurance	Yes	1433	49.9	168	49.1	1265	50.0
		No	1258	43.8	151	44.2	1107	43.8
		Missing	180	6.3	23	6.7	157	6.2
Working Time Arrangements[c]		Regular	1947	67.8	214	62.6	1733	68.5
		Irregular	796	27.7	114	33.3	682	27.0
		Missing	128	4.5	14	4.1	114	4.5
	Shift	Day Shift	2185	76.1	256	74.9	1929	76.3
		Not Day Shift	558	19.4	72	21.1	486	19.2
		Missing	128	4.5	14	4.1	114	4.5
	Hours Per Day	≤ 8	2560	89.2	292	85.4	2268	89.68
		> 8	311	10.8	50	14.6	261	10.3
		Missing	0	0	0	0	0	0
Employability Opportunities[d]		Yes	252	8.8	35	10.2	217	8.6
		No	2491	86.8	284	83.0	2207	87.3
		Missing	128	4.5	23	6.7	105	4.2
Collective Organization[e]		Yes	220	7.7	31	9.1	189	7.5
		No	2496	86.9	297	86.8	2199	87.0
		Missing	155	5.4	14	4.1	141	5.6
Employment		Low	1305	45.5	152	44.4	1153	45.6

Precarity[f]		Medium	607	21.1	75	21.9	532	21.0
		High	959	33.4	115	33.6	844	33.4
		Continuous	2871	--	342	--	2529	--
		Missing	0	0	0	0	0	0

[a] NLSY79: National Longitudinal Survey of Youth 1979
[b] Income was adjusted for inflation to the 1979-dollar value
[c] Women with regular working times had a day shift and worked ≤ 8 hours per day. Women with irregular working times had a non-day shift or worked more than 8 hours per day or had both
[d] Employability opportunities was defined as having employer provided trainings or education
[e] Collective organization was defined as union membership
[f] Employment precarity was categorized based on scores from an index of individual employment characteristics; low: 0-2, medium: 3, high: 4-6

In the fully-adjusted Model 3, women reporting low and medium levels of material rewards had a higher risk of LBW compared to those with a high level of material rewards (RR: 1.37, 95% CI: 1.00-1.87 and RR: 1.44, CI: 1.04-1.99, respectively). Similarly, women with irregular working time arrangements had 1.26 (CI: 1.00-1.60) times the risk of having a LBW infant compared to women with regular working times after adjustment. Individual precarity variables were not associated with increased risk of LBW in this study, except for lack of health insurance in both adjusted models, and income in the lower 50% in Model 2 (Table 3).

Table 3. Risk ratios and 95% Confidence Intervals for the Association Between Employment Precarity and Low Birth Weight in a Sample from the NLSY79 [a] Cohort (1979-2007)

			Model 1 [b]		Model 2 [c]		Model 3 [d]	
			RR [e]	95% CI [f]	RR [e]	95% CI [f]	RR [e]	95% CI [f]
Material Rewards		High	Ref		Ref		Ref	
		Medium	1.06	0.81-1.39	1.40	1.06-1.83	1.37	1.00-1.87
		Low	0.99	0.78-1.26	1.65	1.25-2.18	1.44	1.04-1.99
	Income	Upper 50%	Ref		Ref		Ref	
		Lower 50%	1.00	0.81-1.22	1.51	1.20-1.90	1.28	0.97-1.68
	Insurance	Yes	Ref		Ref		Ref	
		No	1.00	0.82-1.23	1.40	1.12-1.76	1.31	1.01-1.71
Working Time Arrangement[g]		Regular	Ref		Ref		Ref	
		Irregular	1.28	1.04-1.58	1.21	0.98-1.49	1.26	1.00-1.60

	Shift	Day Shift	Ref		Ref		Ref	
		Not Day Shift	1.09	0.85-1.39	1.10	0.86-1.41	1.12	0.85-1.47
	Hours Per Day	≤ 8	Ref		Ref		Ref	
		> 8	1.39	1.06-1.84	1.17	0.89-1.53	1.29	0.94-1.76
Employability Opportunities[h]		Yes	Ref		Ref		Ref	
		No	0.81	0.59-1.11	0.90	0.67-1.21	0.83	0.59-1.18
Collective Organization[i]		Yes	Ref		Ref		Ref	
		No	0.79	0.57-1.09	0.86	0.63-1.19	0.87	0.60-1.28
Employment Precarity[j]		Low	Ref		Ref		Ref	
		Medium	1.06	0.82-1.37	1.26	0.94-1.58	1.34	0.99-1.79
		High	1.03	0.82-1.29	1.49	1.08-1.78	1.49	1.12-1.98
		Continuous	1.02	0.93-1.11	1.14	1.03-1.25	1.17	1.05-1.30

[a] NLSY79: National Longitudinal Survey of Youth 1979
[b] Unadjusted generalized linear model of employment precarity and low birthweight
[c] Model adjusted for maternal age, maternal race/ethnicity, maternal educational attainment, maternal nativity, and infant year of birth
[d] Model adjusted for all covariates in model 2 plus maternal pre-pregnancy BMI, maternal smoking during pregnancy, and maternal alcohol consumption during pregnancy
[e] RR: Risk Ratios
[f] 95% CI: 95% Confidence Intervals
[g] Women with regular working times had a day shift and worked ≤ 8 hours per day. Women with irregular working times had a non-day shift or worked more than 8 hours per day or had both
[h] Employability opportunities was defined as having employer provided trainings or education
[i] Collective organization was defined as union membership
[j] Employment precarity was categorized based on scores from an index of individual employment characteristics; low: 0-2, medium: 3, high: 4-6

The categorical precarity measure was positively associated after adjusting for confounders (Table 3). Women with high employment precarity were more likely to have a LBW infant compared to low employment precarity, after adjustment for all covariates (RR: 1.49, CI: 1.12-1.98). The continuous measure of precarity showed a 1.17 (CI: 1.05-1.30) times higher risk for LBW for a one point higher value in precarity after adjustment for all covariates.

When maternal race/ethnicity and employment precarity were included in an employment precarity-race composite exposure variable, Non-Hispanic Black women saw elevated LBW risk across all employment precarity levels compared to Non-Hispanic White women with low employment precarity (Non-Hispanic Black low precarity: 1.67, CI: 1.08-2.59; medium precarity: 3.03, CI: 1.86-4.92; high precarity: 2.69, CI: 1.73-4.17) (Table 4). Hispanic mothers also saw

higher risk when compared to Non-Hispanic Whites with low precarity (Hispanic low precarity: 1.80, CI: 1.13-2.85; high precarity: 2.55, CI: 1.55-4.19).

Table 4. Risk ratios and 95% Confidence Intervals for the Association Between the Composite Employment Precarity Variable and Low Birth Weight stratified by Maternal Race/Ethnicity in the NLSY79 [a] Cohort (1979-2007)[b]

Employment Precarity	Non-Hispanic White		Hispanic		Non-Hispanic Black	
	RR[c]	95%CI[d]	RR[c]	95%CI[d]	RR[c]	95%CI[d]
Low Precarity	Ref		1.80	1.13-2.85	1.67	1.08-2.59
Medium Precarity	1.34	0.91-1.99	1.66	0.88-3.14	3.03	1.86-4.92
High Precarity	1.46	0.98-2.16	2.55	1.55-4.19	2.69	1.73-4.17

[a] NLSY79: National Longitudinal Survey of Youth 1979
[b] Models are adjusted for maternal age, infant year of birth, maternal educational attainment during pregnancy, maternal nativity, maternal pre-pregnancy BMI, maternal smoking during pregnancy, and maternal alcohol consumption during pregnancy
[c]RR= Risk Ratios
[d]95% CI= Confidence Intervals

DISCUSSION

In this study, we found that women who have high employment precarity prior and/or during pregnancy had a higher risk of giving birth to an LBW infant than women with low employment precarity. Of the individual employment characteristics examined, low material rewards and irregular working time arrangements were associated with LBW. This elevated risk of LBW may be the result of employment-related stress due to these specific employment characteristics.

In addition, we found effect modification by maternal race/ethnicity, with elevated LBW risk in all employment precarity groups in Non-Hispanic Black women and the low and high employment precarity groups in Hispanic women when compared to Non-Hispanic White women with low precarity. This suggests that health inequities exist between these subpopulations and could be a result of different internalizations of stressors from employment precarity or a combination of

workplace and additional life stressors, such as racism and discrimination that women of color disproportionately experience.

Our study is the first to investigate the association between a multidimensional maternal employment precarity construct and infant LBW. Findings were similar to studies examining traditional job stressors, such as job demand/control, that showed higher risk for adverse birth outcomes, such as LBW and preterm birth, in those with poorer quality jobs.[15,24,34] Some older studies and studies conducted outside of the United States did not find job stressors increased the risk for preterm birth and small for gestational age, suggesting that national and temporal contexts may influence the work—pregnancy outcome association.[42,43] This study adds to a growing body of literature that aims to characterize multiple facets of employment quality which extends beyond the more traditional models of job stress, which focus on the psychosocial work environment.[23,44] This study also adds to the literature on inequities in birth outcomes between racial/ethnic groups in the United States and emphasizes the choice of reference groups when conducting research in regard to inequities.[26,27,32,33]

One drawback of this study is the incomplete ascertainment of precarity as laid out by our conceptual framework.[26,40] In particular, data within the NLSY for the dimensions of employment stability, interpersonal power relations, and workers' right and social protections is lacking and is a part of a broader issue that few datasets have robust information on employment precarity. Additionally, misclassification of the exposure may have resulted from our approach to missing data, in which we used data from the year prior to populate missing data for a subsequent year. Further, due to a lack of information on exact date of birth, precarity measures were taken in the interview cycle preceding the year of birth and may represent employment during pregnancy (e.g. birth in January of a given year) or a year prior to the beginning or pregnancy (e.g. birth in December of a given year). Therefore, the exposure may represent different clinically relevant time points for each participant. In regard to the exposure,

we do not believe that validity of self-reported employment characteristics would differ between outcome groups and this nondifferential misclassification may attenuate our estimates. Another source of potential misclassification lies in the self-reported outcome data; however, a past study found high correlation between maternal recall of infant birth weight many years after pregnancy and birth weight obtained during pregnancy.[45] Residual and unmeasured confounding was also a limitation. Data on pregnancy risk factors, partner's employment status and social support networks may also have been important unmeasured confounders. Finally, sampling for this study was based on the population residing in the United States in 1979 and was employed during or prior to pregnancy. It may not be representative to today's sociodemographic distribution or the risk of LBW for those without a job or searching for employment.

Future research should focus on elucidating the employment precarity—LBW relationship through a more complete ascertainment of the exposure, including indicators from all seven precarity dimensions and a better assessment of the most relevant maternal employment period (e.g. prior to or concurrent with pregnancy) for birth outcomes. Researchers interested in employment precarity and birth outcomes may also consider including data on things such as availability of paid family leave as these types of policies are of particular relevance to women. Investigating the role of paternal employment precarity as an exposure for adverse birth outcomes may also be a fruitful avenue of research.

The findings from our study may better inform prenatal care for working women. Clinicians treating women who plan to work during their pregnancy should consider asking their patients about their employment conditions and recommend resources that may mitigate the effects of employment precarity. These findings may also inform potential workplace policies or practices, such as altering working times or ensuring benefits to pregnant employees to better support women during their pregnancy. Altering workplace practices can be best aided by local, state, or

federal policies that require that these accommodations be made by employers while women are working during pregnancy. Our findings support greater examination of employment precarity and health, especially as a larger proportion of women enter and remain in the workforce.

Author's Contribution

Ms. Patil was responsible for analysis and interpretation of the data as well as writing the paper.

Dr. Enquobahrie substantively revised the manuscript for important intellectual content.

Mr. Peckham contributed to the conception of the study and substantively revised the manuscript for important intellectual content.

Dr. Seixas substantively revised the manuscript for important intellectual content.

Dr. Hajat conceived and designed the study and contributed to interpretation of data. She also substantively revised the manuscript and oversaw the project.

All authors reviewed and approved of the submitted version and are accountable for ensuring accuracy and integrity of the work.

There is no one else who fulfils the criteria that has been excluded as an author.

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References

1 Wang SF, Shu L, Sheng J et al. Birth weight and risk of coronary heart disease in adults: a meta-analysis of prospective cohort studies. *J Dev Orig Health Dis* 2014;5:408-19.

2 Zarrati M, Shidfar F, Razmpoosh E et al. Does low birth weight predict hypertension and obesity in schoolchildren? *Ann Nutr Metab* 2013;63:69-76.

3 McCormick MC. The Contribution of Low Birth Weight to Infant Mortality and Childhood Morbidity. *N Engl J Med* 1985;312:82-90.

4 Hack M, Flannery DJ, Schluchter M, Cartar L, Borawski E, Klein N. Outcomes in Young Adulthood for Very-Low-Birth-Weight Infants. *N Engl J Med* 2002;346:149-57.

5 Behrman JR, Rosenzweig MR. Returns to Birthweight. *Rev Econ Stat* 2004;86:586-601.

6 Martin JA, Hamilton BE, Osterman MJ, Discoll AK, Drake P. Births: Final data for 2016 2018.

7 Bernabé JVd, Soriano T, Albaladejo R et al. Risk factors for low birth weight: a review. *Eur J Obstet Gynecol Reprod Biol* 2004;116:3-15.

8 United States Department of Labor. Women's Bureau (WB) - Women in the Labor Force.

9 Mathews TJ, Hamilton BE. Mean Age of Mothers is on the Rise: United States, 2000-2014. *NCHS data brief* 2016:1-8.

10 Burdorf A, Figà-Talamanca I, Jensen TK, Thulstrup AM. Effects of occupational exposure on the reproductive system: core evidence and practical implications. *Occup Med* 2006;56:516-20.

11 Figà-Talamanca I. Occupational risk factors and reproductive health of women. *Occup Med* 2006;56:521-31.

12 Henriksen TB, Hedegaard M, Secher NJ. Standing and walking at work and birthweight. *Acta Obstet Gynecol Scad* 1995;74:509-16.

13 Florack EI, Pellegrino AE, Zielhis GA, Rolland R. Influence of occupational physical activity on pregnancy duration and birthweight. *Scand J Work Environ Health* 1995;21:199-207.

14 Palmer KT, Bonzini M, Harris EC, Linaker C, Bonde JP. Work activities and risk of prematurity, low birth weight and pre-eclampsia: an updated review with meta-analysis. *Occup Environ Med* 2013;70:213-22.

15 Katz VL. Work and Work-related Stress in Pregnancy. *Clin Obstet Gynecol* 2012;55:765-73.

16 Lee B-E, Ha M, Park H et al. Psychosocial work stress during pregnancy and birthweight. *Paediatr Perinat Epidemiol* 2011;25:246-54.

17 Karasek RA. Job Demands, Job Decision Latitude, and Mental Strain: Implications for Job Redesign. *Adm Sci Q* 1979;24:285-308.

18 Peckham TK, Baker MG, Camp JE, Kaufman JD, Seixas NS. Creating a Future for Occupational Health. *Ann Work Expo Health* 2017;61:3-15.

19 Weil D. *The fissured workplace: Why work became so bad for so many and what can be done to improve it*. Cambridge, Massachusetts London: Harvard University Press, 2014.

20 Bosch G. Towards a New Standard Employment Relationship in Western Europe. *Br J Ind Relat* 2004;42:617-36.

21 Kalleberg AL. *Good jobs, bad jobs: the rise of polarized and precarious employment systems in the United States, 1970s to 2000s*. New York, NY: Russel Sage Foundation, 2013.

22 Benach J, Vives A, Amable M, Vanroelen C, Tarafa G, Muntaner C. Precarious Employment: Understanding an Emerging Social Determinant of Health. *Annu Rev Public Health* 2014;35:229-53.

23 Scott-Marshall H, Tompa E. The health consequences of precarious employment experiences. *Work* 2011;38:369-82.

24 Dooley D, Prause J. Birth Weight and Mothers' Adverse Employment Change. *J Health Soc Behav* 2005;46:141-55.

25 Kalleberg AL. Precarious Work, Insecure Workers: Employment Relations in Transition. *Am Sociol Rev* 2009;74:1-22.

26 Julià M, Vanroelen C, Bosmans K, Van Aerden K, Benach J. Precarious Employment and Quality of Employment in Relation to Health and Well-being in Europe. *Int J Health Serv* 2017;47:389-409.

27 Lewchuk W, Clarke M, de Wolff A. Working without commitments: precarious employment and health. *Work Employ Soc* 2008;22:387-406.

28 Sandman CA, Wadhwa PD, Dunkel-Schetter C et al. Psychobiological Influences of Stress and HPA Regulation on the Human Fetus and Infant Birth Outcomesa. *Ann N Y Acad Sci* 1994;739:198-210.

29 O'Donnell K, O'Connor TG, Glover V. Prenatal Stress and Neurodevelopment of the Child: Focus on the HPA Axis and Role of the Placenta. *Dev Neurosci* 2009;31:285-92.

30 Sandman CA, Wadhwa PD, Chicz-DeMet A, Dunkel-Schetter C, Porto M. Maternal Stress, HPA Activity, and Fetal/Infant Outcomea. *Ann N Y Acad Sci* 1997;814:266-75.

31 Tompa E, Scott-Marshall H, Dolinschi R, Trevithick S, Bhattacharyya S. Precarious employment experiences and their health consequences: Towards a theoretical framework. *Work* 2007;28:209-24.

32 Lane SD, Keefe RH, Rubinstein R et al. Structural violence, urban retail food markets, and low birth weight. *Health Place* 2008;14:415-23.

33 Luo Z-C, Wilkins R, Kramer MS. Effect of neighbourhood income and maternal education on birth outcomes: a population-based study. *CMAJ* 2006;174:1415-20.

34 Casas M, Cordier S, Martínez D et al. Maternal occupation during pregnancy, birth weight, and length of gestation: combined analysis of 13 European birth cohorts. *Scand J Work Environ Health* 2015;41:384-96.

35 Larsen AD, Hannerz H, Juhl M et al. Psychosocial job strain and risk of adverse birth outcomes: a study within the Danish national birth cohort. *Occup Environ Med* 2013;70:845-51.

36 Lu MC, Halfon N. Racial and Ethnic Disparities in Birth Outcomes: A Life-Course Perspective. *Matern Child Health J* 2003;7:13-30.

37 Cramer JC. Racial and Ethnic Differences in Birthweight: The Role of Income and Financial Assistance. *Demography* 1995;32:231-47.

38 Menéndez M, Benach J, Muntaner C, Amable M, O'Campo P. Is precarious employment more damaging to women's health than men's? *Soc Sci Med* 2007;64:776-81.

39 Hippie S. Contingent Work in the Late-1990s. *Mon Labor Rev* 2001;124:3.

40 Eurofound. Quality of Employment Conditions and Employment Relations in Europe *Eurofound, Dublin, Ireland* 2013.

41 VanderWeele TJ, Knol MJ. A Tutorial on Interaction. *Epidemiol Methods* 2014;3:33-72.

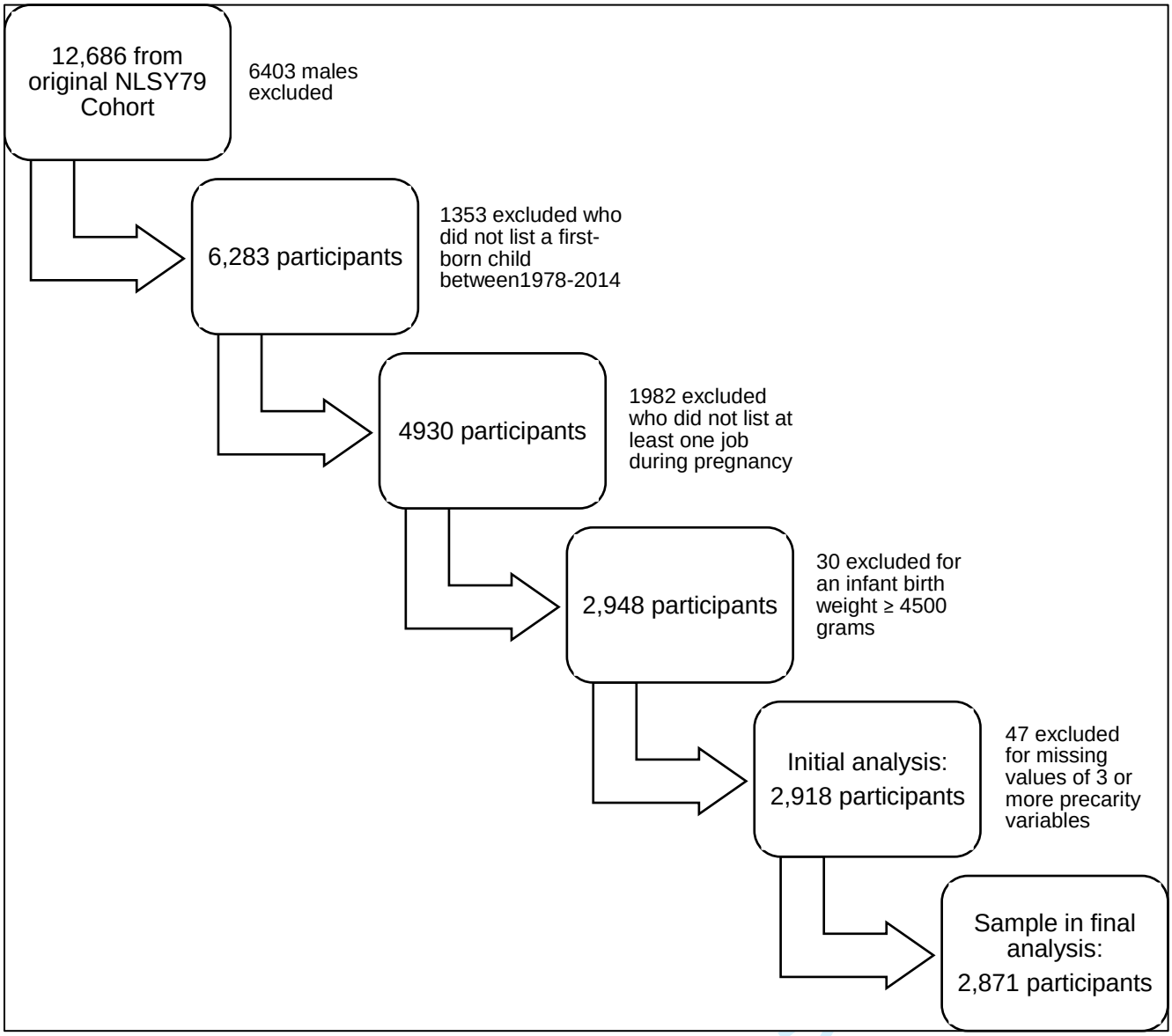
42 Larsen AD. The effect of maternal exposure to psychosocial job strain on pregnancy outcomes and child development. *Danish Medical Journal* 2015;62.

43 Homer CJ, Beresford SAA, Jarnes SA, Siegel E, Wilcox S. Work-related physical exertion and risk of preterm, low birthweight delivery. *Paediatr Perinat Epidemiol* 1990;4:161-74.

44 Vives A, Amable M, Ferrer M et al. The Employment Precariousness Scale (EPRES): psychometric properties of a new tool for epidemiological studies among waged and salaried workers. *Occup Environ Med* 2010;67:548-55.

45 Tomeo CA, Rich-Edwards JW, Michels KB et al. Reproducibility and Validity of Maternal Recall of Pregnancy-Related Events. *Epidemiology* 1999;10:774.

Figure 1. Exclusion Criteria for Participants in the NLSY79 Cohort (1979-2007)



STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6-10
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6-7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-9
Bias	9	Describe any efforts to address potential sources of bias	8,9
Study size	10	Explain how the study size was arrived at	Fig. 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9,10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9,10
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, explain how loss to follow-up was addressed	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6,7
		(b) Give reasons for non-participation at each stage	6,7
		(c) Consider use of a flow diagram	Fig. 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10,11
		(b) Indicate number of participants with missing data for each variable of interest	11-12
		(c) Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13,14
		(*b*) Report category boundaries when continuous variables were categorized	7-9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14,15
Discussion			
Key results	18	Summarise key results with reference to study objectives	15
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	16,17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	3

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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A Retrospective Cohort Study of the Association Between Maternal Employment Precarity and Infant Low Birth Weight in Women in the United States

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A Retrospective Cohort Study of the Association Between Maternal Employment Precarity and Infant Low Birth Weight in Women in the United States

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Abstract

Objectives: To investigate the association between maternal employment precarity, the multidimensional construct characterized by instability, lack of protection and insecurity in employment, and infant low birth weight (LBW), and to assess if this association differs by race/ethnicity.

Methods: Data were collected from 2,871 women enrolled in the National Longitudinal Survey of Youth 1979 and the National Longitudinal Survey of Youth Children Cohort. Employment precarity was characterized as a composite measure of four employment characteristics (material rewards [score 0-2], working time arrangements [score 0-2], collective organization [score 0-1], and employability opportunities [score 0-1]) and categorized into three groups low (0-2), medium (3), and high (4-6). LBW was defined as weight less than 2500 grams at birth. Generalized linear models were fit to calculate risk ratios and 95% confidence intervals and adjusted for maternal age, race/ethnicity, educational attainment, nativity, pre-pregnancy body mass index, alcohol consumption, smoking during pregnancy and infant year of birth. We assessed effect modification by maternal race/ethnicity using a composite exposure variable.

Results: Women with high (RR: 1.49, 95%CI: 1.12-1.98) employment precarity had higher risk of a LBW delivery compared to women with low employment precarity. Compared to Non-Hispanic White women with low employment precarity, Non-Hispanic Black women (RR: 2.69; 95%CI: 1.73-4.17), Hispanic women (RR: 2.55; 95%CI: 1.55-4.19), and Non-Hispanic White women (RR: 1.46; 95%CI: 0.98-2.16) with high employment precarity had higher risk of LBW.

Conclusions: Findings of this study can be used to inform antenatal care and identify workplace policies to better support women who work during pregnancy.

Strengths and limitations of this study

- Our study is the first to use a multidimensional definition of employment precarity to study its association with low birthweight.
- Data was collected from a diverse cohort of women living in the United States, allowing us to examine the racial/ethnic differences in the association between employment precarity and low birthweight.
- This study could benefit from data on more dimensions of employment precarity and additional confounding variables.

What this paper adds?

1. What is already known about this subject?

   Traditional job stressors, such as job demand/control, have been associated with higher risk for adverse birth outcomes. In addition, atypical or non-permanent contracts, long working hours, and shift work have also been associated with preterm birth,

2. What this study adds?

   Our study is the first to use a multidimensional definition of employment precarity. We found that women with higher employment precarity had higher risk of low birth weight and this risk differed by race/ethnicity. Our findings can inform workplace policies to better support women during pregnancy.

Funding Statement

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Competing Interests Statement

None declared

INTRODUCTION

Low birth weight (LBW) is associated with many chronic conditions in later life, including obesity, hypertension, and coronary heart diseases.[1,2] Infants born with LBW are at a higher risk of death in the first year of life and lower educational attainment and income earnings in adult life.[3-5] The prevalence of LBW deliveries in the United States has remained stagnant for more than two decades, with proportions recorded at about 7% in 1990 and 8% in 2016.[6] LBW disparities have also been recorded between racial/ethnic groups; in 2016 13.7% of infants born to Non-Hispanic Black women were LBW, compared to 7.0% and 7.3% of those born to Non-Hispanic White and Hispanic mothers, respectively.[6] While some exposures, such as income, maternal chronic conditions before and during pregnancy, and behavioral factors including smoking, have been established as risk factors of LBW, the stable prevalence over time and observed disparities in LBW suggest that further examination of potential risk factors should be considered.[7]

As of 2016, woman made up 46.8% of the total U.S. labor force— among women in their prime reproductive age (25-34 years) nearly 75% were working. A growing number of studies have investigated maternal occupational exposures during pregnancy and birth outcomes.[8,9] Several studies have found associations with abnormal birth outcomes and work-related chemical exposures (e.g., solvents, toxic metals) and/or physical hazards (e.g., lifting, standing for long durations), although contradictory evidence exists.[10-14] A smaller number of studies have found associations between LBW and work-related psychosocial exposures, for example job strain as measured by the Job Demand-Control model.[15-17] These studies all focus on job content and working conditions, i.e., the nature of tasks and the physical and social environment in which work takes place; however, the relational and contractual aspects of employment have received less attention as potential risk factors for LBW. This is despite widespread concerns that the nature and structure of employment have dramatically changed in recent decades

toward more flexible, less secure employment arrangements.[18-21] Indeed, a growing body of research has identified the terms and conditions of the employee-employer relationship--which determine contract type, wages and benefits, hours, schedule, mobility opportunities, and workplace power dynamics--as important job-related determinants of health.[22,23]

Some indicators of employment conditions, when evaluated in isolation, have been associated with higher risk of LBW, including atypical or non-permanent contracts, long working hours, and shift work.[14,24] However, jobs are better conceived as a composite of several simultaneously occurring employment conditions, and it is the aggregation of these features that determine a worker's experience—such as whether a job is health-enhancing or deleterious. In other words, studies focused only on a single characteristic would fail to capture the complexity of contemporary employment arrangements. This has led to increased research attention to the multidimensional construct of precarious employment.[22] Employment precarity can be defined as an accumulation of poor employment conditions that produce an experience of unstable, insecure employment, with inadequate wages and benefits and lacking social protections.[25,26]

While employment precarity has been linked to several adverse health outcomes, no studies have applied this multidimensional construct to the study of LBW.[22] Precarious employment can influence birth outcomes through several mechanisms. Most directly, precarious employment may cause maternal stress, such as through job insecurity, lack of control, or powerlessness.[26,27] Perinatal stress is thought to impact the hypothalamic pituitary adrenal (HPA) axis and affect fetal growth during pregnancy.[28-30] Furthermore, workers in precarious employment arrangements may have difficulty obtaining sufficient and stable income, as well as non-wage benefits.[26,31] This material deprivation could lead to impoverished living conditions or poor nutrition, which have been linked to LBW.[32,33]

The few studies evaluating individual employment conditions and birth outcomes were conducted outside of the United States, where different labor laws and social safety nets exist.[34,35] Further, few studies considered potential differences by racial/ethnic groups despite observed disparities in LBW.[36,37] This is especially relevant given evidence that precarious employment is socially distributed such that women, people of color, immigrants, younger workers, lower-skilled, and lower-educated workers are disproportionately represented.[38,39]

This study is the first to use a multidimensional definition of employment precarity to examine its association with infant LBW using a large, nationally representative cohort in the United States. We further examined differences in this association by race/ethnicity.

METHODS

The National Longitudinal Study of Youth (NLSY79), conducted by the United States Bureau of Labor Statistics, is a nationally representative longitudinal cohort (N=12,686) of individuals born between 1957 and 1964 and living in the United States at the start of the survey in 1979. From 1979 - 1994 NLSY79 data were collected annually; beginning in 1996 biennial data collection began and is ongoing. The NLSY79 Children cohort (N=11,521) began in 1986 and surveyed all children born to female respondents in the original cohort. The NLSY79 Children is linked to the original NLSY79 Cohort using the mother's ID to allow linkages across mother-infant pairs. At the start of data collection, 50% of the NLSY79 Cohort was female. As of 2014, the retention rate for the entire cohort is 71.0%.

This study included women enrolled in the NLSY79 Cohort who had a child enrolled in the NLSY79 Children cohort. Women were excluded if they did not have a singleton first child born between 1978 to 2014 (N=1,353), did not list at least one job in the interview cycle during the birth year of their first child (N=1,982), had an infant with a birth weight of 4500 grams or more

(n=30), or had missing information on three or more work characteristics that were used to calculate the exposure (N=47). The final sample included in the analysis was 2,871 women (Figure 1). We excluded unemployed women to improve exchangeability of exposed and unexposed groups. The last birth of a first-born child occurred in 2007 for women in the NLSY79, resulting in complete ascertainment of first births for this cohort. The Institutional Review Board at the University of Washington deemed this study to be exempt. Data used in this study are freely available on the NLSY website.

Patient and Public Involvement

Study participants were not involved in the development of the research question or the implementation of the study.

Exposure

The primary exposure was maternal employment precarity measured in the interview cycle preceding infant birth. Precarity is conceptualized based on a framework used in a growing number of health studies in the European Union, which includes the following seven dimensions: (1) employment stability; (2) material rewards; (3) workers' rights and social protections; (4) working time arrangements; (5) training and employability opportunities; (6) collective organization; and (7) interpersonal power relations.[26,40] In this study we operationalized precarity using available indicators of employment conditions within four of the seven dimensions. *Material rewards* was scored as high, medium, or low based on two criteria: having employer-provided insurance (yes/no) and income in the last year adjusted for inflation to 1979 dollars (upper 50% of sample or lower 50% of sample). Those who had both employer-provided insurance and an income in the upper 50% of the sample were categorized as high (score of 0), those with either employer-provided insurance or an income in the upper 50% of the sample were considered medium (1), and those with no employer-provided insurance or an

income in the lower 50% of the sample were considered low (2). *Working time arrangements* was categorized as regular and irregular determined by participants' working hours per day (<=8 hours, >8 hours), and time of day working (day time, non-day time). Participants working <=8 hours a day and during the day were considered to have regular working times (0), those either working >8 hours or in a non-day time shift and those working both >8 hours and a non-day time shift were considered irregular (1-2). Training and e*mployability opportunities* was based on whether employers provided training or education to participants (0) or did not (1). *Collective organization* was determined by an indicator of union membership (or whether wages are set by a union if union membership was not asked in that survey year), with membership scored as 0 and no membership as 1. These four characteristics of employment are measured during the interview cycle prior to infant birth year and were summed to create an employment precarity composite measure ranging from 0 to 6, with higher scores reflecting greater employment precarity. Participants were further categorized into three groups based on their employment precarity composite score: low employment precarity (0-2), medium (3), and high (4-6). These cutoffs were determined based on the distribution of the employment precarity scores. During some survey years, questions pertaining to these work precarity dimensions were not asked. For those years, data from the previous survey cycle was used in place of the missing information.

Outcome

The outcome of interest was maternal-reported infant LBW defined as birth weight of less than 2500 grams (5 pounds, 8 ounces). An infant with birth weight of 2500-4500 grams was considered normal birth weight.

Covariates

Several maternal covariates were included in the analyses: race/ethnicity (Non-Hispanic White, Non-Hispanic Black or Hispanic), age, educational attainment at time of pregnancy (less than high school, high school degree, or more than high school), nativity (born in or outside of the United States), pre-pregnancy body mass index (BMI) calculated from self-reported height and weight, smoking during pregnancy (smoked at least once versus no smoking during pregnancy), alcohol consumption during pregnancy (any versus no alcohol consumption), as well as infant year of birth and infant sex (male or female). Race/ethnicity was considered a confounder and an effect modifier. All other covariates were included as confounders in the employment precarity-LBW relationship. Maternal age and pre-pregnancy BMI were treated as continuous variables. Confounders and effect modifiers were chosen a priori based on existing literature on employment precarity and birth outcomes and based on a directed acyclic graph constructed for this analysis.

Statistical Analysis

Though NLSY79 provides sampling weights to adjust for oversampling, we did not use them in our analysis because of the large number of exclusions we made. All of our analysis was done using unweighted data. Descriptive statistics were used to compare sociodemographic and behavioral characteristics across employment precarity groups. To assess the relationship between employment precarity and infant LBW, a series of generalized linear models were fit to estimate risk ratios and their corresponding 95% confidence intervals. We evaluated precarious employment in three different ways. First, the association between each individual employment precarity component (material rewards, working time arrangements, employability opportunities, and collective organization), as well as variables used to create these components (income, insurance, shift time, and hours worked), and LBW were examined. Second, we evaluated the composite precarity measure specified as a categorical variable (low, medium, and high). Lastly, we evaluated a continuous specification of the composite measure. Because sociodemographic

and behavioral factors individually have associations with both employment precarity and LBW, we used a staged modelling approach for all three specifications of the exposure in order to delineate the different confounding effects of these two groups of variables. Model 1 was an unadjusted generalized linear regression. Model 2 was adjusted for sociodemographic covariates including maternal age, maternal race/ethnicity, maternal educational attainment, maternal nativity, and infant year of birth. Race/ethnicity, nativity and (in most cases) education were measured prior to employment and are likely strong confounders of the precarious employment – LBW association. Model 3 was additionally adjusted for behavioral factors, including maternal pre-pregnancy BMI, and maternal smoking and alcohol use during pregnancy; this was considered our primary model.

It is possible that smoking and alcohol use are on the causal pathway between precarious employment and LBW, though it is unlikely that a woman would initiate smoking and higher levels of alcohol consumption during pregnancy. Smoking is often initiated in adolescents and early adulthood; one study indicated about 82% of smokers initiated smoking before age 21. [41] The mean age of our study participants was 24 years old. As for alcohol consumption, it has been shown to stop or decrease dramatically after women learned of their pregnancy. [42] Using the staged modelling approach presented here allows readers to consider model 2 as primary if concerns about adjustment for smoking and alcohol persist.

We examined effect modification by race/ethnicity using the approach recommended by VanderWeele and colleagues (2014) which created an employment precarity-race composite variable that combines the effect modifier and the exposure.[43] The reference group was low employment precarity in Non-Hispanic White women. Risk ratios and corresponding 95% confidence intervals were calculated using fully adjusted generalized linear models to explore effect modification. Analyses were conducted using SAS 9.4 and statistical significance was determined using the $p<0.05$ cut-off.

RESULTS

Among study participants, 45% (N=1,305) had low employment precarity, 21% (N=607) had medium employment precarity, and 33% (N=959) had high employment precarity. High and medium employment precarity had a higher prevalence of younger and Non-Hispanic Black or Hispanic women compared to low employment precarity (Table 1). High and medium employment precarity also had a higher proportion of less than high school educated women and smoking during pregnancy. High employment precarity had a smaller proportion of women who consumed alcohol compared to women with low employment precarity. Mean age at first birth was higher for low employment precarity (26.0, SD: 5.5) and lower for medium and high precarity (24.5, SD: 4.9 and 21.7, SD: 3.8). Pre-pregnancy BMI was higher for low and medium employment precarity (24.0, SD: 4.6 and 23.5, SD: 4.6) compared to high employment precarity (23.5, SD: 4.6). Overall, 88% (N=2529) of participants delivered normal birthweight infants and 12% (N=342) delivered LBW infants (97 non-Hispanic black women, 67 Hispanic women and 178 non-Hispanic white women delivered LBW infants).

Table 1. Selected Sociodemographic Characteristics of Study Participants from the NLSY79 [a] Cohort (1979-2007)

	Entire Sample (N=2871)		Low Employment Precarity (N=1305)		Medium Employment Precarity (N= 607)		High Employment Precarity (N=959)	
	N or Mean	% or SD	N or Mean	% or SD	N or Mean	% or SD	N or Mean	% or SD
Age (years)	24.3	5.2	26.0	5.5	24.5	4.9	21.7	3.8
Missing	0	0	0	0	0	0	0	0
Pre-Pregnancy Body Mass Index (kg/m^2)[b]	23.8	5.4	24.0	4.6	23.9	7.6	23.5	4.6
Missing	94	3.3	51	3.9	15	2.5	28	2.9
Maternal Race/ Ethnicity								
Non-Hispanic Black	600	20.9	262	20.1	106	17.5	232	24.2
Hispanic	495	17.2	212	16.2	95	15.7	188	19.6
Non-Hispanic White	1776	61.9	831	63.7	406	66.9	539	56.2
Missing	0	0	0	0	0	0	0	0
Maternal Nativity								
In the United States	2682	93.4	1222	93.6	571	94.1	889	92.7

Outside of the United States	189	6.6	83	6.4	36	5.9	70	7.3
Missing	0	0	0	0	0	0	0	0
Maternal Educational Attainment								
Less than High School	479	16.7	144	11.0	78	12.9	257	26.8
High School	1231	42.9	503	38.5	272	44.8	456	47.6
More than High School	1161	40.4	658	50.4	257	42.3	246	25.7
Missing	0	0	0	0	0	0	0	0
Infant Sex								
Male	1420	49.5	670	51.3	294	48.4	456	47.6
Female	1451	50.5	635	48.7	313	51.6	503	52.5
Missing	0	0	0	0	0	0	0	0
Maternal Smoking								
Smoked at Least Once	811	28.3	317	24.3	174	28.7	320	33.4
Did Not Smoke	1916	66.7	913	70.0	409	67.4	594	61.9
Missing	144	5.0	75	5.8	24	4.0	45	4.7
Maternal Alcohol								
Consumed at Least Once	1336	46.5	633	48.5	300	49.2	403	42.0
Did Not Consume Alcohol	1392	48.5	598	45.8	282	46.5	512	53.4
Missing	143	5.0	74	5.7	25	4.1	44	4.6

[a] NLSY79: National Longitudinal Survey of Youth 1979

[b] Body Mass Index calculated using self-reported height and self-report weight

Missingness for employment precarity variables was similar between outcome groups (Table 2). All precarity variables had a missingness below 6% except for material rewards and insurance.

Table 2. Descriptive statistics of maternal employment precarity by percent of low and normal birth weight, NLSY79 [a] Cohort (1979-2007)

			Entire Sample (N=2871)		Low Birth Weight		Normal Birth Weight	
			N	%	N	%	N	%
Material Rewards		High	1102	38.4	129	37.7	973	38.5
		Medium	546	19.0	69	20.2	477	18.9
		Low	891	31.0	105	30.7	786	31.1
		Missing	332	11.6	39	11.4	293	11.6
	Income[b]	Upper 50%	1327	46.2	159	46.5	1168	46.2
		Lower 50%	1385	48.2	164	48.0	1221	48.3
		Missing	159	5.5	19	5.6	140	5.5
	Insurance	Yes	1433	49.9	168	49.1	1265	50.0
		No	1258	43.8	151	44.2	1107	43.8

		Missing	180	6.3	23	6.7	157	6.2
Working Time Arrangements[c]		Regular	1947	67.8	214	62.6	1733	68.5
		Irregular	796	27.7	114	33.3	682	27.0
		Missing	128	4.5	14	4.1	114	4.5
	Shift	Day Shift	2185	76.1	256	74.9	1929	76.3
		Not Day Shift	558	19.4	72	21.1	486	19.2
		Missing	128	4.5	14	4.1	114	4.5
	Hours Per Day	≤ 8	2560	89.2	292	85.4	2268	89.68
		> 8	311	10.8	50	14.6	261	10.3
		Missing	0	0	0	0	0	0
Employability Opportunities[d]		Yes	252	8.8	35	10.2	217	8.6
		No	2491	86.8	284	83.0	2207	87.3
		Missing	128	4.5	23	6.7	105	4.2
Collective Organization[e]		Yes	220	7.7	31	9.1	189	7.5
		No	2496	86.9	297	86.8	2199	87.0
		Missing	155	5.4	14	4.1	141	5.6
Employment Precarity[f]		Low	1305	45.5	152	44.4	1153	45.6
		Medium	607	21.1	75	21.9	532	21.0
		High	959	33.4	115	33.6	844	33.4
		Continuous	2871	--	342	--	2529	--
		Missing	0	0	0	0	0	0

[a] NLSY79: National Longitudinal Survey of Youth 1979
[b] Income was adjusted for inflation to the 1979-dollar value
[c] Women with regular working times had a day shift and worked ≤ 8 hours per day. Women with irregular working times had a non-day shift or worked more than 8 hours per day or had both
[d] Employability opportunities was defined as having employer provided trainings or education
[e] Collective organization was defined as union membership
[f] Employment precarity was categorized based on scores from an index of individual employment characteristics; low: 0-2, medium: 3, high: 4-6

In the fully-adjusted Model 3, women reporting low and medium levels of material rewards had a higher risk of LBW compared to those with a high level of material rewards (RR: 1.37, 95% CI: 1.00-1.87 and RR: 1.44, CI: 1.04-1.99, respectively). Similarly, women with irregular working time arrangements had 1.26 (CI: 1.00-1.60) times the risk of having a LBW infant compared to

women with regular working times after adjustment. Individual precarity variables were not associated with increased risk of LBW in this study, except for lack of health insurance in both adjusted models, and income in the lower 50% in Model 2 (Table 3).

Table 3. Risk ratios and 95% Confidence Intervals for the Association Between Employment Precarity and Low Birth Weight in a Sample from the NLSY79 [a] Cohort (1979-2007)

			Model 1 [b]		Model 2 [c]		Model 3 [d]	
			RR [e]	95% CI [f]	RR [e]	95% CI [f]	RR [e]	95% CI [f]
Material Rewards		High	Ref		Ref		Ref	
		Medium	1.06	0.81-1.39	1.40	1.06-1.83	1.37	1.00-1.87
		Low	0.99	0.78-1.26	1.65	1.25-2.18	1.44	1.04-1.99
	Income	Upper 50%	Ref		Ref		Ref	
		Lower 50%	1.00	0.81-1.22	1.51	1.20-1.90	1.28	0.97-1.68
	Insurance	Yes	Ref		Ref		Ref	
		No	1.00	0.82-1.23	1.40	1.12-1.76	1.31	1.01-1.71
Working Time Arrangement[g]		Regular	Ref		Ref		Ref	
		Irregular	1.28	1.04-1.58	1.21	0.98-1.49	1.26	1.00-1.60
	Shift	Day Shift	Ref		Ref		Ref	
		Not Day Shift	1.09	0.85-1.39	1.10	0.86-1.41	1.12	0.85-1.47
	Hours Per Day	≤ 8	Ref		Ref		Ref	
		> 8	1.39	1.06-1.84	1.17	0.89-1.53	1.29	0.94-1.76
Employability Opportunities[h]		Yes	Ref		Ref		Ref	
		No	0.81	0.59-1.11	0.90	0.67-1.21	0.83	0.59-1.18
Collective Organization[i]		Yes	Ref		Ref		Ref	
		No	0.79	0.57-1.09	0.86	0.63-1.19	0.87	0.60-1.28
Employment Precarity[j]		Low	Ref		Ref		Ref	
		Medium	1.06	0.82-1.37	1.26	0.94-1.58	1.34	0.99-1.79
		High	1.03	0.82-1.29	1.49	1.08-1.78	1.49	1.12-1.98
		Continuous	1.02	0.93-1.11	1.14	1.03-1.25	1.17	1.05-1.30

[a] NLSY79: National Longitudinal Survey of Youth 1979

[b] Unadjusted generalized linear model of employment precarity and low birthweight

[c] Model adjusted for maternal age, maternal race/ethnicity, maternal educational attainment, maternal nativity, and infant year of birth

[d] Model adjusted for all covariates in model 2 plus maternal pre-pregnancy BMI, maternal smoking during pregnancy, and maternal alcohol consumption during pregnancy

[e] RR: Risk Ratios

[f] 95% CI: 95% Confidence Intervals

[g] Women with regular working times had a day shift and worked ≤ 8 hours per day. Women with irregular working times had a non-day shift or worked more than 8 hours per day or had both

[h] Employability opportunities was defined as having employer provided trainings or education
[i] Collective organization was defined as union membership
[j] Employment precarity was categorized based on scores from an index of individual employment characteristics; low: 0-2, medium: 3, high: 4-6

The categorical precarity measure was positively associated with LBW after adjusting for confounders (Table 3). Women with high employment precarity were more likely to have a LBW infant compared to low employment precarity, after adjustment for all covariates (RR: 1.49, CI: 1.12-1.98). The continuous measure of precarity showed a 1.17 (CI: 1.05-1.30) times higher risk for LBW for a one point higher value in precarity after adjustment for all covariates.

When maternal race/ethnicity and employment precarity were included in an employment precarity-race composite exposure variable, Non-Hispanic Black women had elevated LBW risk across all employment precarity levels compared to Non-Hispanic White women with low employment precarity (Non-Hispanic Black low precarity: 1.67, CI: 1.08-2.59; medium precarity: 3.03, CI: 1.86-4.92; high precarity: 2.69, CI: 1.73-4.17) (Table 4). Hispanic mothers also saw higher risk when compared to Non-Hispanic Whites with low precarity (Hispanic low precarity: 1.80, CI: 1.13-2.85; high precarity: 2.55, CI: 1.55-4.19).

Table 4. Risk ratios and 95% Confidence Intervals for the Association Between the Composite Employment Precarity Variable and Low Birth Weight stratified by Maternal Race/Ethnicity in the NLSY79 [a] Cohort (1979-2007)[b]

Employment Precarity	Non-Hispanic White			Hispanic			Non-Hispanic Black		
	RR[c]	95%CI[d]	N	RR[c]	95%CI[d]	N	RR[c]	95%CI[d]	N
Low Precarity	Ref		831	1.80	1.13-2.85	212	1.67	1.08-2.59	262
Medium Precarity	1.34	0.91-1.99	406	1.66	0.88-3.14	95	3.03	1.86-4.92	106
High Precarity	1.46	0.98-2.16	539	2.55	1.55-4.19	188	2.69	1.73-4.17	232

[a] NLSY79: National Longitudinal Survey of Youth 1979
[b] Models are adjusted for maternal age, infant year of birth, maternal educational attainment during pregnancy, maternal nativity, maternal pre-pregnancy BMI, maternal smoking during pregnancy, and maternal alcohol consumption during pregnancy
[c]RR= Risk Ratios
[d]95% CI= Confidence Intervals

CONCLUSION

In this study, we found that women who have high employment precarity prior and/or during pregnancy had a higher risk of giving birth to an LBW infant than women with low employment precarity. Of the individual employment characteristics examined, low material rewards and irregular working time arrangements were associated with LBW. This elevated risk of LBW may be the result of employment-related stress due to these specific employment characteristics.

In addition, we found effect modification by maternal race/ethnicity, with elevated LBW risk in all employment precarity groups in Non-Hispanic Black women and the low and high employment precarity groups in Hispanic women when compared to Non-Hispanic White women with low precarity. Though the medium precarity Hispanic group did not have significant findings, this may be the result of a lack of statistical power. This suggests that health inequities exist between these subpopulations and could be a result of different internalizations of stressors from employment precarity or a combination of workplace and additional life stressors, such as racism and discrimination that women of color disproportionately experience.

Our study is the first to investigate the association between a multidimensional maternal employment precarity construct and infant LBW. Findings were similar to studies examining traditional job stressors, such as job demand/control, that showed higher risk for adverse birth outcomes, such as LBW and preterm birth, in those with poorer quality jobs.[15,24,34] Some older studies and studies conducted outside of the United States did not find job stressors increased the risk for preterm birth and small for gestational age, suggesting that national and temporal contexts may influence the work—pregnancy outcome association.[44,45] This study adds to a growing body of literature that aims to characterize multiple facets of employment quality which extends beyond the more traditional models of job stress, which focus on the psychosocial work environment.[23,46] This study also adds to the literature on inequities in

birth outcomes between racial/ethnic groups in the United States and emphasizes the choice of reference groups when conducting research in regard to inequities.[26,27,32,33]

One drawback of this study is the incomplete ascertainment of precarity as laid out by our conceptual framework.[26,40] In particular, data within the NLSY for the dimensions of employment stability, interpersonal power relations, and workers' right and social protections is lacking and is a part of a broader issue that few datasets have robust information on employment precarity. It is also possible that the existing variables we use to define the dimensions of precarity may not fully capture those dimensions. Additional research on defining precarity, specifically in the US context, is needed to better evaluate the measurement of this multi-dimensional construct. Furthermore, other employment related variables such as full vs part-time status over the course of the year prior to pregnancy would have also been helpful to better understand precarious employment but were not available in the NLSY. Additionally, misclassification of the exposure may have resulted from our approach to missing data, in which we used data from the year prior to populate missing data for a subsequent year. Further, due to a lack of information on exact date of birth, precarity measures were taken in the interview cycle preceding the year of birth and may represent employment during pregnancy (e.g. birth in January of a given year) or a year prior to the beginning of pregnancy (e.g. birth in December of a given year). Therefore, the exposure may represent different clinically relevant time points for each participant. In regard to the exposure, we do not believe that validity of self-reported employment characteristics would differ between outcome groups and this nondifferential misclassification may attenuate our estimates. Another source of potential misclassification lies in the self-reported outcome data; however, a past study found high correlation between maternal recall of infant birth weight many years after pregnancy and birth weight obtained during pregnancy.[47] Though some infants may be LBW as a result of a preterm birth, we did not have information on gestational age and could not distinguish between full term LBW and

preterm LBW infants, which may be important as these two birth outcomes may have different etiological pathways. Residual and unmeasured confounding was also a limitation. Data on pregnancy risk factors, partner's employment status, their fringe benefits and social support networks may also have been important unmeasured confounders. Sample sizes for racial and ethnic groups were small when assessing differences in the employment precarity-LBW association by subgroup, thus impacting our power to detect an effect. Finally, sampling for this study was based on the population residing in the United States in 1979 and was employed during or prior to pregnancy. It may not be representative to today's sociodemographic distribution or the risk of LBW for those without a job or searching for employment.

Future research should focus on elucidating the employment precarity-LBW relationship through a more complete ascertainment of the exposure, including indicators from all seven precarity dimensions and a better assessment of the most relevant maternal employment period (e.g. prior to or concurrent with pregnancy) for birth outcomes. Researchers interested in employment precarity and birth outcomes may also consider including data on things such as availability of paid family leave as these types of policies are of particular relevance to women as well as oversampling racial/ethnic groups to assess differences in subpopulations. Investigating the role of paternal employment precarity as an exposure for adverse birth outcomes may also be a fruitful avenue of research. Because the data we used did not distinguish between unemployed individuals looking for paid work and those not seeking employment, we could not include a reference group of women seeking employment. However, future research should consider including these women as a reference group, especially in an effort to further understand the gig economy.The findings from our study may better inform prenatal care for working women. Clinicians treating women who plan to work during their pregnancy should consider asking their patients about their employment conditions and recommend resources that may mitigate the effects of employment precarity. These findings

may also inform potential workplace policies or practices, such as altering working times or ensuring benefits to pregnant employees to better support women during their pregnancy. Altering workplace practices can be best aided by local, state, or federal policies that require that these accommodations be made by employers while women are working during pregnancy. Our findings support greater examination of employment precarity and health, especially as a larger proportion of women enter and remain in the workforce.

Author's Contribution

Ms. Patil was responsible for analysis and interpretation of the data as well as writing the paper.

Dr. Enquobahrie substantively revised the manuscript for important intellectual content.

Mr. Peckham contributed to the conception of the study and substantively revised the manuscript for important intellectual content.

Dr. Seixas substantively revised the manuscript for important intellectual content.

Dr. Hajat conceived and designed the study and contributed to interpretation of data. She also substantively revised the manuscript and oversaw the project.

All authors reviewed and approved of the submitted version and are accountable for ensuring accuracy and integrity of the work.

There is no one else who fulfils the criteria that has been excluded as an author.

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Data Availability

Data is publicly accessible through the United States Bureau of Labor Statistic's website for National Longitudinal Surveys: https://www.nlsinfo.org/content/cohorts/nlsy79/get-data.

Figure 1. Exclusion criteria for participants in the NLSY79 cohort (1979-2007)

References

1 Wang SF, Shu L, Sheng J et al. Birth weight and risk of coronary heart disease in adults: a meta-analysis of prospective cohort studies. *Journal of Developmental Origins of Health and Disease* 2014;5:408-19.
2 Zarrati M, Shidfar F, Razmpoosh E et al. Does low birth weight predict hypertension and obesity in schoolchildren? *Ann Nutr Metab* 2013;63:69-76.
3 McCormick MC. The Contribution of Low Birth Weight to Infant Mortality and Childhood Morbidity. *N Engl J Med* 1985;312:82-90.
4 Hack M, Flannery DJ, Schluchter M, Cartar L, Borawski E, Klein N. Outcomes in Young Adulthood for Very-Low-Birth-Weight Infants. *N Engl J Med* 2002;346:149-57.
5 Behrman JR, Rosenzweig MR. Returns to Birthweight. *The Review of Economics and Statistics* 2004;86:586-601.
6 Martin JA, Hamilton BE, Osterman MJ, Discoll AK, Drake P. Births: Final data for 2016 2018.
7 Bernabé JVd, Soriano T, Albaladejo R et al. Risk factors for low birth weight: a review. *European Journal of Obstetrics and Gynecology and Reproductive Biology* 2004;116:3-15.
8 United States Department of Labor. Women's Bureau (WB) - Women in the Labor Force.
9 Mathews TJ, Hamilton BE. Mean Age of Mothers is on the Rise: United States, 2000-2014. *NCHS data brief* 2016:1-8.
10 Burdorf A, Figà-Talamanca I, Jensen TK, Thulstrup AM. Effects of occupational exposure on the reproductive system: core evidence and practical implications. *Occup Med* 2006;56:516-20.
11 Figà-Talamanca I. Occupational risk factors and reproductive health of women. *Occup Med* 2006;56:521-31.
12 Henriksen TB, Hedegaard M, Secher NJ. Standing and walking at work and birthweight. *Acta Obstet Gynecol Scad* 1995;74:509-16.
13 Florack EI, Pellegrino AE, Zielhis GA, Rolland R. Influence of occupational physical activity on pregnancy duration and birthweight. *Scandinavian Journal of Work, Environment & Health* 1995;21:199-207.
14 Palmer KT, Bonzini M, Harris EC, Linaker C, Bonde JP. Work activities and risk of prematurity, low birth weight and pre-eclampsia: an updated review with meta-analysis. *Occup Environ Med* 2013;70:213-22.
15 Katz VL. Work and Work-related Stress in Pregnancy. *Clin Obstet Gynecol* 2012;55:765-73.
16 Lee B-E, Ha M, Park H et al. Psychosocial work stress during pregnancy and birthweight. *Paediatr Perinat Epidemiol* 2011;25:246-54.
17 Karasek RA. Job Demands, Job Decision Latitude, and Mental Strain: Implications for Job Redesign. *Adm Sci Q* 1979;24:285-308.
18 Peckham TK, Baker MG, Camp JE, Kaufman JD, Seixas NS. Creating a Future for Occupational Health. *Annals of Work Exposures and Health* 2017;61:3-15.
19 Weil D. *The fissured workplace: Why work became so bad for so many and what can be done to improve it*. Cambridge, Massachusetts London: Harvard University Press, 2014.
20 Bosch G. Towards a New Standard Employment Relationship in Western Europe. *British Journal of Industrial Relations* 2004;42:617-36.
21 Kalleberg AL. *Good jobs, bad jobs: the rise of polarized and precarious employment systems in the United States, 1970s to 2000s*. New York, NY: Russel Sage Foundation, 2013.
22 Benach J, Vives A, Amable M, Vanroelen C, Tarafa G, Muntaner C. Precarious Employment: Understanding an Emerging Social Determinant of Health. *Annu Rev Public Health* 2014;35:229-53.

23 Scott-Marshall H, Tompa E. The health consequences of precarious employment experiences. *Work* 2011;38:369-82.

24 Dooley D, Prause J. Birth Weight and Mothers' Adverse Employment Change. *J Health Soc Behav* 2005;46:141-55.

25 Kalleberg AL. Precarious Work, Insecure Workers: Employment Relations in Transition. *Am Sociol Rev* 2009;74:1-22.

26 Julià M, Vanroelen C, Bosmans K, Van Aerden K, Benach J. Precarious Employment and Quality of Employment in Relation to Health and Well-being in Europe. *Int J Health Serv* 2017;47:389-409.

27 Lewchuk W, Clarke M, de Wolff A. Working without commitments: precarious employment and health. *Work, Employment and Society* 2008;22:387-406.

28 Sandman CA, Wadhwa PD, Dunkel-Schetter C et al. Psychobiological Influences of Stress and HPA Regulation on the Human Fetus and Infant Birth Outcomesa. *Ann N Y Acad Sci* 1994;739:198-210.

29 O'Donnell K, O'Connor TG, Glover V. Prenatal Stress and Neurodevelopment of the Child: Focus on the HPA Axis and Role of the Placenta. *Dev Neurosci* 2009;31:285-92.

30 Sandman CA, Wadhwa PD, Chicz-DeMet A, Dunkel-Schetter C, Porto M. Maternal Stress, HPA Activity, and Fetal/Infant Outcomea. *Ann N Y Acad Sci* 1997;814:266-75.

31 Tompa E, Scott-Marshall H, Dolinschi R, Trevithick S, Bhattacharyya S. Precarious employment experiences and their health consequences: Towards a theoretical framework. *Work* 2007;28:209-24.

32 Lane SD, Keefe RH, Rubinstein R et al. Structural violence, urban retail food markets, and low birth weight. *Health & Place* 2008;14:415-23.

33 Luo Z-C, Wilkins R, Kramer MS. Effect of neighbourhood income and maternal education on birth outcomes: a population-based study. *CMAJ* 2006;174:1415-20.

34 Casas M, Cordier S, Martínez D et al. Maternal occupation during pregnancy, birth weight, and length of gestation: combined analysis of 13 European birth cohorts. *Scandinavian Journal of Work, Environment & Health* 2015;41:384-96.

35 Larsen AD, Hannerz H, Juhl M et al. Psychosocial job strain and risk of adverse birth outcomes: a study within the Danish national birth cohort. *Occup Environ Med* 2013;70:845-51.

36 Lu MC, Halfon N. Racial and Ethnic Disparities in Birth Outcomes: A Life-Course Perspective. *Maternal and Child Health Journal* 2003;7:13-30.

37 Cramer JC. Racial and Ethnic Differences in Birthweight: The Role of Income and Financial Assistance. *Demography* 1995;32:231-47.

38 Menéndez M, Benach J, Muntaner C, Amable M, O'Campo P. Is precarious employment more damaging to women's health than men's? *Soc Sci Med* 2007;64:776-81.

39 Hippie S. Contingent Work in the Late-1990s. *Mon Labor Rev* 2001;124:3.

40 Eurofound. Quality of Employment Conditions and Employment Relations in Europe *Eurofound, Dublin, Ireland* 2013.

41 Choi SH, Stommel M. Impact of Age at Smoking Initiation on Smoking-Related Morbidity and All-Cause Mortality. Am J Prev Med. 2017 Jul 1;53(1):33–41.

42 Pryor J, Patrick SW, Sundermann AC, Wu P, Hartmann KE. Pregnancy Intention and Maternal Alcohol Consumption. Obstet Gynecol. 2017;129(4):727–33.

43 VanderWeele TJ, Knol MJ. A Tutorial on Interaction. *Epidemiologic Methods* 2014;3:33-72.

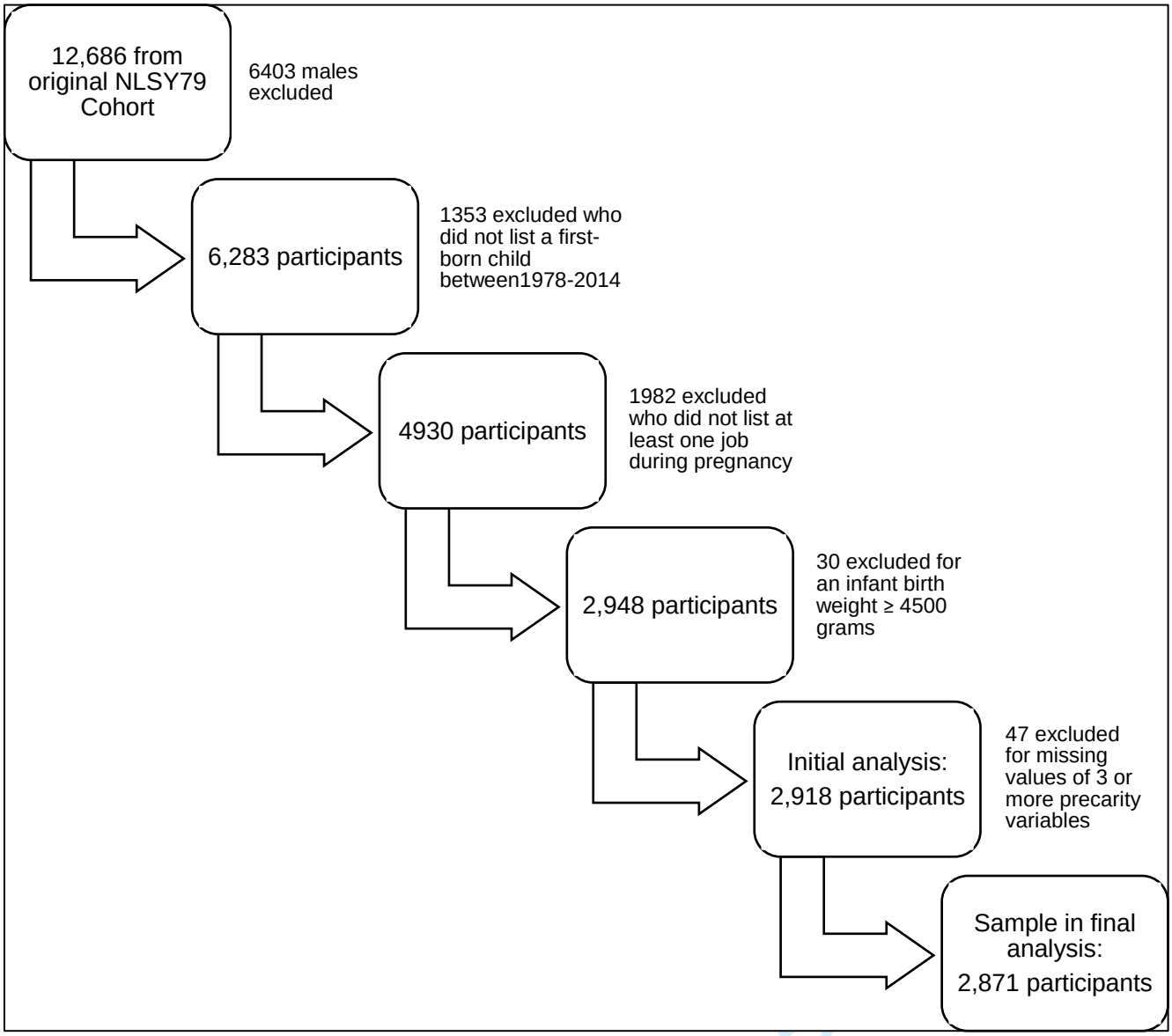
44 Larsen AD. The effect of maternal exposure to psychosocial job strain on pregnancy outcomes and child development. *Danish Medical Journal* 2015;62.

45 Homer CJ, Beresford SAA, Jarnes SA, Siegel E, Wilcox S. Work-related physical exertion and risk of preterm, low birthweight delivery. *Paediatr Perinat Epidemiol* 1990;4:161-74.

46 Vives A, Amable M, Ferrer M et al. The Employment Precariousness Scale (EPRES): psychometric properties of a new tool for epidemiological studies among waged and salaried workers. *Occup Environ Med* 2010;67:548-55.

47 Tomeo CA, Rich-Edwards JW, Michels KB et al. Reproducibility and Validity of Maternal Recall of Pregnancy-Related Events. *Epidemiology* 1999;10:774.

Figure 1. Exclusion Criteria for Participants in the NLSY79 Cohort (1979-2007)



STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6-10
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6-7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-9
Bias	9	Describe any efforts to address potential sources of bias	8,9
Study size	10	Explain how the study size was arrived at	Fig. 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9,10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9,10
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, explain how loss to follow-up was addressed	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6,7
		(b) Give reasons for non-participation at each stage	6,7
		(c) Consider use of a flow diagram	Fig. 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10,11
		(b) Indicate number of participants with missing data for each variable of interest	11-12
		(c) Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13,14
		(*b*) Report category boundaries when continuous variables were categorized	7-9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14,15
Discussion			
Key results	18	Summarise key results with reference to study objectives	15
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	16,17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	3

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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A Retrospective Cohort Study of the Association Between Maternal Employment Precarity and Infant Low Birth Weight in Women in the United States

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A Retrospective Cohort Study of the Association between Maternal Employment Precarity and Infant Low Birth Weight in Women in the United States

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Keywords: employment precarity, contingent work, non-standard work, employment quality, low birthweight, pregnancy, reproductive health, work

Word Count: 3244

Abstract

Objectives: To investigate the association between maternal employment precarity and infant low birth weight (LBW), and to assess if this association differs by race/ethnicity.

Methods: Data were collected from 2,871 women enrolled in the National Longitudinal Survey of Youth 1979 and the National Longitudinal Survey of Youth Children Cohort. Employment precarity was evaluated using a summary variable that combined several employment attributes: availability of employer-sponsored insurance, income, long shifts, non-daytime shifts, availability of employer sponsored training or educational benefits and membership in a union or collective bargaining unit. Employment precarity scores (a sum of the number of negative employment attributes) were categorized into low (0-2), medium (3), and high (4-6). LBW was defined as weight less than 2500 grams at birth. Modified Poisson models were fit to calculate risk ratios and 95% confidence intervals and adjusted for maternal age, race/ethnicity, educational attainment, nativity, pre-pregnancy body mass index, alcohol consumption, smoking during pregnancy and infant year of birth. We assessed effect modification by maternal race/ethnicity using a composite exposure-race variable.

Results: Women with high employment precarity had higher risk of a LBW delivery compared to women with low employment precarity (RR: 1.48, 95%CI: 1.11-1.98). Compared to non-Hispanic/non-Black women with low employment precarity, non-Hispanic Black women (RR: 2.68; 95%CI: 1.72-4.15), Hispanic women (RR: 2.53; 95%CI: 1.54-4.16), and non-Hispanic/non-Black women (RR: 1.46; 95%CI: 0.98-2.16) with high employment precarity had higher risk of LBW.

Conclusions: We observed higher risk of LBW in pregnancies of women with high employment precarity; this association was stronger among Black and Hispanic mothers compared to non-

Hispanic/non-Black women. Findings of this study can be used to inform antenatal care and identify workplace policies to better support women who work during pregnancy.

Strengths and limitations of this study

- Our study is the first to use a multidimensional definition of employment precarity to study its association with low birthweight.
- Data was collected from a diverse cohort of women living in the United States, allowing us to examine the racial/ethnic differences in the association between employment precarity and low birthweight.
- This study could benefit from data on more dimensions of employment precarity and additional confounding variables.

What this paper adds?

1. What is already known about this subject?

   Traditional job stressors, such as job demand/control, have been associated with higher risk for adverse birth outcomes. In addition, atypical or non-permanent contracts, long working hours, and shift work have also been associated with preterm birth,

2. What this study adds?

   Our study is the first to use a multidimensional definition of employment precarity. We found that women with higher employment precarity had higher risk of low birth weight and this risk differed by race/ethnicity. Our findings may inform workplace policies to better support women during pregnancy.

Funding Statement

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Competing Interests Statement

None declared

INTRODUCTION

Low birth weight (LBW) is associated with many chronic conditions in later life, including obesity, hypertension, and coronary heart diseases.[1,2] Infants born with LBW are at a higher risk of death in the first year of life and lower educational attainment and income earnings in adult life.[3-5] The prevalence of LBW deliveries in the United States has remained stagnant for more than two decades, with proportions recorded at about 7% in 1990 and 8% in 2016.[6] LBW disparities have also been recorded between racial/ethnic groups; in 2016 13.7% of infants born to Non-Hispanic Black women were LBW, compared to 7.0% and 7.3% of those born to Non-Hispanic White and Hispanic mothers, respectively.[6] While some exposures (such as income, maternal chronic conditions before and during pregnancy) and behavioral factors (including smoking) have been established as risk factors of LBW, the stable prevalence over time and observed disparities in LBW suggest that further examination of potential risk factors should be considered.[7]

As of 2016, woman made up 46.8% of the total U.S. labor force; among women in their prime reproductive age (25-34 years), nearly 75% were working. A growing number of studies have investigated maternal occupational exposures during pregnancy and birth outcomes.[8,9] Several studies have found associations with abnormal birth outcomes and work-related chemical exposures (e.g., solvents, toxic metals) and/or physical hazards (e.g., lifting, standing for long durations), although contradictory evidence exists.[10-14] A smaller number of studies have found associations between LBW and work-related psychosocial exposures, for example job strain as measured by the Job Demand-Control model.[15-17] These studies all focus on job content and working conditions, i.e., the nature of tasks and the physical and social environment in which work takes place; however, the relational and contractual aspects of employment have received less attention as potential risk factors for LBW. This is despite widespread concerns that the nature and structure of employment have dramatically changed in recent decades

toward more flexible, less secure employment arrangements.[18-21] Indeed, a growing body of research has identified the terms and conditions of the employee-employer relationship--which determine contract type, wages and benefits, hours, schedule, mobility opportunities, and workplace power dynamics--as important job-related determinants of a host of physical and mental health outcomes.[22,23]

Some indicators of employment conditions, when evaluated in isolation, have been associated with higher risk of LBW; this includes atypical or non-permanent contracts, long working hours, and shift work.[14,24] However, jobs typically have several simultaneously occurring employment conditions, and it is the aggregation of these features that likely determine a worker's experience—such as whether a job is health-enhancing or deleterious. In other words, studies focused only on a single characteristic would fail to capture the complexity of contemporary employment arrangements. This has led to increased research attention to the multidimensional construct of precarious employment.[22] Employment precarity can be defined as an accumulation of poor employment conditions that produce an experience of unstable, insecure employment, with inadequate wages and benefits and lacking social protections.[25,26] In this study we conceptualized precarity based on a framework used in a growing number of health studies in the European Union, which includes the following seven dimensions: (1) employment stability; (2) material rewards; (3) workers' rights and social protections; (4) working time arrangements; (5) training and employability opportunities; (6) collective organization; and (7) interpersonal power relations.[26,27]

While employment precarity has been linked to several adverse health outcomes, no studies have applied this multidimensional construct to the study of LBW.[22] Precarious employment can influence birth outcomes through several mechanisms. Most directly, precarious employment may cause maternal stress, due to job insecurity, lack of control, or powerlessness.[26,28] Perinatal stress is thought to impact the hypothalamic pituitary adrenal

(HPA) axis and affect fetal growth during pregnancy.[29-31] Furthermore, workers in precarious employment arrangements may have difficulty obtaining sufficient and stable income, as well as non-wage benefits.[26,32] This material deprivation could lead to impoverished living conditions or poor nutrition, which have been linked to LBW.[33,34] Lastly, unpredictable work arrangements and the lack of paid leave may create barriers for women to receive timely prenatal care . [35]

The few studies evaluating employment characteristics (such as job strain and occupational sector) and birth outcomes were conducted outside of the United States, where different labor laws and social safety nets exist.[36,37] Further, few studies considered potential differences by racial/ethnic groups despite observed disparities in LBW.[38,39] This is especially relevant given evidence that precarious employment is socially distributed such that women, people of color, immigrants, younger workers, lower-skilled, and lower-educated workers are disproportionately represented.[40,41]

This study is the first to use a multidimensional definition of employment precarity to examine its association with infant LBW using a large, nationally representative cohort in the United States. We further examined differences in this association by race/ethnicity.

METHODS

The National Longitudinal Study of Youth (NLSY79), conducted by the United States Bureau of Labor Statistics, is a nationally representative longitudinal cohort (N=12,686) of individuals born between 1957 and 1964 and living in the United States at the start of the survey in 1979. The NLSY79 Children cohort (N=11,521) began in 1986 and surveyed all female respondents in the original cohort about their pregnancies and the health of their children; like the parent study (NLSY79) this survey was administered every year until 1996, after which it was administered every two years. The NLSY79 Children is linked to the original NLSY79 Cohort using the

mother's ID to allow linkages across mother-infant pairs. At the start of data collection, 50% of the NLSY79 Cohort was female. As of 2014, the retention rate for the entire cohort is 71.0%.

This study included women enrolled in the NLSY79 Cohort and consented to having their child included in the NLSY79 Children cohort. Women were excluded if they did not have a singleton first child born between 1978 to 2014 (N=1,353), did not list at least one job in the interview cycle preceding the birth year of their first child during the survey period (1979 – 2014) (N=1,982), had an infant with a birth weight of 4500 grams or more (n=30), or had missing information on three or more precarity dimensions that were used to calculate the exposure (N=47). The final sample included in the analysis was 2,871 women (Figure 1). We excluded unemployed women to improve exchangeability of exposed and unexposed groups. The last birth of a first-born child occurred in 2007 for women in the NLSY79, resulting in complete ascertainment of first births for this cohort. The Institutional Review Board at the University of Washington deemed this study to be exempt. Data used in this study are freely available on the NLSY website.

Patient and Public Involvement

Study participants were not involved in the development of the research question or the implementation of the study.

Exposure

The primary exposure was maternal employment precarity measured in the interview cycle preceding infant birth characterized by the following seven dimensions: (1) employment stability; (2) material rewards; (3) workers' rights and social protections; (4) working time arrangements; (5) training and employability opportunities; (6) collective organization; and (7) interpersonal power relations.[26,27] In this study we operationalized employment precarity using available indicators of employment conditions within four of the seven dimensions. *Material rewards* was

scored as high, medium, or low based on two criteria: having employer-provided insurance (yes/no) and income in the last year adjusted for inflation to 1979 dollars (upper 50% of sample or lower 50% of sample). Those who had both employer-provided insurance and an income in the upper 50% of the sample were categorized as high (score of 0), those with either employer-provided insurance or an income in the upper 50% of the sample were considered medium (1), and those with no employer-provided insurance or an income in the lower 50% of the sample were considered low (2). *Working time arrangements* was categorized as regular and irregular determined by participants' working hours per day (<=8 hours, >8 hours), and time of day working (day time, non-day time). Participants working <=8 hours a day and during the day were considered to have regular working times (0), those either working >8 hours or in a non-day time shift and those working both >8 hours and a non-day time shift were considered irregular (1-2). Training and e*mployability opportunities* were based on whether employers provided training or education to participants (0) or did not (1). *Collective organization* was determined by an indicator of union membership (or whether wages are set by a union if union membership was not asked in that survey year), with membership scored as 0 and no membership as 1. For women with more than one job, all characteristics pertain to the first job respondents reported. These four characteristics of employment are measured during the interview cycle prior to infant birth year and were summed to create an employment precarity composite measure ranging from 0 to 6, with higher scores reflecting greater employment precarity. Participants were further categorized into three groups based on their employment precarity composite score: low employment precarity (0-2), medium (3), and high (4-6). These cutoffs were determined using tertiles based on the distribution of the employment precarity scores. During some survey years, questions pertaining to these work precarity dimensions were not asked. For those years, data from the previous survey cycle was used in place of the missing information.

Outcome

The outcome of interest was maternal-reported infant LBW defined as birth weight of less than 2500 grams (5 pounds, 8 ounces). An infant with birth weight of 2500-4500 grams was considered normal birth weight.

Covariates

Several maternal covariates were included in the analyses: race/ethnicity (Non-Hispanic/Non-Black, Non-Hispanic Black or Hispanic), age, educational attainment at time of pregnancy (less than high school, high school degree, or more than high school), nativity (born in or outside of the United States), pre-pregnancy body mass index (BMI) calculated from self-reported height and weight, smoking during pregnancy (smoked at least once versus no smoking during pregnancy), alcohol consumption during pregnancy (any versus no alcohol consumption), as well as infant year of birth and infant sex (male or female). Data to break down the Non-Hispanic/Non-Black group were not provided. Race/ethnicity was considered a confounder and an effect modifier and is being conceptualized as a proxy for racism and discrimination. All other covariates were included as confounders in the employment precarity–LBW relationship. Maternal age and pre-pregnancy BMI were treated as continuous variables. Confounders and effect modifiers were chosen a priori based on existing literature on employment precarity and birth outcomes and based on a directed acyclic graph constructed for this analysis.

Statistical Analysis

The NLSY79 provides sampling weights to adjust for oversampling, clustering and non-response. We used the weights to compute descriptive statistics (Tables 1 and 2) but not estimates from multivariable models as there is concern that parameter estimates would be biased [42,43]. Descriptive statistics were used to compare sociodemographic and behavioral characteristics across employment precarity groups. For multivariable analysis we used modified Poisson regression models to estimate risk ratios and their corresponding 95%

confidence intervals. These models were used because log binomial models did not converge in many instances and logistic models would overestimate parameter estimates since LBW is not rare. We evaluated precarious employment in three different ways. First, the association between each individual employment precarity component (material rewards, working time arrangements, employability opportunities, and collective organization), as well as variables used to create these components (income, insurance, shift time, and hours worked), and LBW were examined. Second, we evaluated the composite precarity measure specified as a categorical variable (low, medium, and high). Lastly, we evaluated a continuous specification of the composite measure.

We used three different adjustment models to delineate the different confounding effects of the sociodemographic and behavioral variables. . Model 1 was an unadjusted generalized linear regression. Model 2 was adjusted for sociodemographic covariates including maternal age, maternal race/ethnicity, maternal educational attainment, maternal nativity, and infant year of birth. Race/ethnicity, nativity and (in most cases) education were measured prior to employment and are likely strong confounders of the precarious employment – LBW association. Model 3 was adjusted for behavioral factors, including maternal pre-pregnancy BMI, maternal smoking, alcohol use during pregnancy and all the variables in model 2; this was considered our primary model.

It is possible that smoking and alcohol use are on the causal pathway between precarious employment and LBW, though it is unlikely that a woman would initiate smoking and higher levels of alcohol consumption during pregnancy. Smoking is often initiated in adolescents and early adulthood; one study indicated about 82% of smokers initiated smoking before age 21. [44] The mean age of our study participants was 24 years old. As for alcohol consumption, it has been shown to stop or decrease dramatically after women learned of their pregnancy. [45]

Using the three different adjustment models presented above allows readers to consider model 2 as primary if concerns about adjustment for smoking and alcohol persist.

We examined effect modification by race/ethnicity using the approach recommended by VanderWeele and colleagues (2014) which created an employment precarity-race composite variable that combines the effect modifier and the exposure.[44] The reference group was low employment precarity in non-Hispanic/non-Black women. Risk ratios and corresponding 95% confidence intervals were calculated using fully adjusted modified Poisson models. As a sensitivity analysis, we collapsed the three-level employment precarity variable to two categories in order to make comparisons between low precarity women and the medium and high precarity women. Analyses were conducted using SAS 9.4 and statistical significance was determined using the $p<0.05$ cut-off.

RESULTS

Among study participants, 45% (N=1,305) had low employment precarity, 31% (N=607) had medium employment precarity, and 24% (N=959) had high employment precarity. High and medium employment precarity had a higher prevalence of Non-Hispanic Black or Hispanic women compared to low employment precarity (Table 1). High and medium employment precarity also had a higher proportion of less than high school educated women and smoking during pregnancy. High employment precarity had a smaller proportion of women who consumed alcohol compared to women with low employment precarity. Mean age at first birth was higher for low employment precarity (26.4, SE: 0.89) and lower for medium and high precarity (23.5, SE: 1.48 and 21.5, SE: 0.81). Overall, 85% (N=2529) of participants delivered normal birthweight infants and 15% (N=342) delivered LBW infants (97 non-Hispanic black women, 67 Hispanic women and 178 non-Hispanic/non-Blackwomen delivered LBW infants).

Table 1. Weighted[a] Sociodemographic Characteristics of Study Participants from the NLSY79[b] Cohort (1979-2007)

	Entire Sample (N=2871)		Low Employment Precarity (N=1305)		Medium Employment Precarity (N= 607)		High Employment Precarity (N=959)	
	N or Mean	% or SE	N or Mean	% or SE	N or Mean	% or SE	N or Mean	% or SE
Age (years)	24.3	0.78	26.4	0.89	23.5	1.48	21.5	0.81
Missing	0	0	0	0	0	0	0	0
Pre-Pregnancy Body Mass Index (kg/m^2)[c]	23.2	0.45	230	0.28	23.7	0.65	22.0	1.20
Missing	94	1.5	51	1.9	15	0.8	28	1.6
Maternal Race/ Ethnicity								
Non-Hispanic Black	600	13.7	262	16.9	106	4.0	232	20.0
Hispanic	495	6.3	212	5.9	95	12.3	188	4.9
Non-Hispanic/non-Black	1776	80.0	831	80.2	406	83.7	539	75.0
Missing	0	0	0	0	0	0	0	0
Maternal Nativity								
In the United States	2682	94.7	1222	97.8	571	88.2	889	97.0
Outside of the United States	189	5.3	83	2.2	36	11.8	70	3.0
Missing	0	0	0	0	0	0	0	0
Maternal Educational Attainment								
Less than High School	479	13.1	144	3.7	78	27.3	257	12.7
High School	1231	45.2	503	42.7	272	29.4	456	69.7
More than High School	1161	41.7	658	53.6	257	43.3	246	17.7
Missing	0	0	0	0	0	0	0	0
Infant Sex								
Male	1420	53.3	670	40.3	294	67.1	456	59.9
Female	1451	46.7	635	59.7	313	32.9	503	40.1
Missing	0	0	0	0	0	0	0	0
Maternal Smoking								
Smoked at Least Once	811	32.6	317	20.9	174	34.4	320	51.9
Did Not Smoke	1916	63.3	913	72.1	409	64.4	594	45.6
Missing	144	4.1	75	7.0	24	1.1	45	2.5
Maternal Alcohol								
Consumed at Least Once	1336	45.9	633	68.2	300	26.9	403	28.5
Did Not Consume Alcohol	1392	50.0	598	24.8	282	72.0	512	69.0
Missing	143	4.1	74	7.0	25	1.2	44	2.5

a Sample weights derived from the Bureau of Labor Statistics National Longitudinal Surveys custom weighting program; means, standard error and percentages are weighted, N's are unweighted
b NLSY79: National Longitudinal Survey of Youth 1979
c Body Mass Index calculated using self-reported height and self-report weight

Missingness for employment precarity variables was similar between outcome groups (Table 2). All precarity variables had a unweighted missingness below 6% except for material rewards and insurance.

Table 2. Weighted[a] descriptive statistics of maternal employment precarity by percent of low and normal birth weight, NLSY79[b] Cohort (1979-2007)

			Entire Sample (N=2871)		Low Birth Weight (n=342)		Normal Birth Weight (n=2529)	
			N	%	N	%	N	%
Material Rewards		High	1102	44.0	129	79.6	973	37.7
		Medium	546	21.1	69	8.2	477	23.4
		Low	891	30.1	105	9.0	786	34.0
		Missing	332	4.7	39	3.2	293	5.0
	Income[c]	Upper 50%	1354	60.5	159	83.3	1194	41.2
		Lower 50%	1358	37.2	164	14.9	1195	56.4
		Missing	159	2.3	19	1.8	140	2.4
	Insurance	Yes	1433	49.3	168	84.0	1265	43.1
		No	1258	48.3	151	14.3	1107	54.3
		Missing	180	2.5	23	1.7	157	2.6
Working Time Arrangements[d]		Regular	1947	73.0	214	86.7	1733	70.5
		Irregular	796	24.4	114	12.6	682	26.5
		Missing	128	2.7	14	0.7	114	3.0
	Shift	Day Shift	2185	79.8	256	91.7	1929	77.6
		Not Day Shift	558	17.6	72	7.6	486	19.4
		Missing	128	2.7	14	0.7	114	3.0
	Hours Per Day	≤ 8	2560	84.7	292	94.1	2268	83.0
		> 8	311	15.3	50	5.9	261	17.0
		Missing	0	0	0	0	0	0
Employability		Yes	252	19.3	35	4.8	217	21.9

Opportunities[e]		No	2491	78.4	284	92.5	2207	75.9
		Missing	128	2.3	23	2.7	105	2.2
Collective Organization[f]		Yes	220	3.7	31	3.3	189	3.7
		No	2496	93.7	297	95.1	2199	93.4
		Missing	155	2.6	14	1.6	141	0.6
Employment Precarity[g]		Low	1305	45.0	152	80.9	1153	38.6
		Medium	607	30.5	75	8.6	532	34.5
		High	959	24.4	115	10.6	844	26.9
		Continuous	2871	--	342	--	2529	--
		Missing	0	0	0	0	0	0

a Sample weights derived from the Bureau of Labor Statistics National Longitudinal Surveys custom weighting program; means, standard error and percentages are weighted, N's are unweighted
b NLSY79: National Longitudinal Survey of Youth 1979
c Income was adjusted for inflation to the 1979-dollar value
d Women with regular working times had a day shift and worked ≤ 8 hours per day. Women with irregular working times had a non-day shift or worked more than 8 hours per day or had both
e Employability opportunities was defined as having employer provided trainings or education
f Collective organization was defined as union membership
g Employment precarity was categorized based on scores from an index of individual employment characteristics; low: 0-2, medium: 3, high: 4-6

In the fully-adjusted Model 3, women reporting low and medium levels of material rewards had a higher risk of LBW compared to those with a high level of material rewards (RR: 1.39, 95% CI: 1.01, 1.91 and RR: 1.40, CI: 1.01, 1.94, respectively). Similarly, women with irregular working time arrangements had 1.27 (CI: 1.00, 1.61) times the risk of having a LBW infant compared to women with regular working times after adjustment. Individual precarity variables were not associated with increased risk of LBW in this study, except for lack of health insurance in both adjusted models, and income in the lower 50% in Model 2 (Table 3).

Table 3. Risk ratios and 95% Confidence Intervals for the Association Between Employment Precarity and Low Birth Weight in a Sample from the NLSY79[a] Cohort (1979-2007)

			Model 1[b]		Model 2[c]		Model 3[d]	
			RR[e]	95% CI[f]	RR[e]	95% CI[f]	RR[e]	95% CI[f]

Material Rewards		High	Ref		Ref		Ref	
		Medium	1.08	0.82-1.42	1.35	1.02-1.79	1.39	1.01-1.91
		Low	1.01	0.79-1.28	1.45	1.08-1.95	1.40	1.01-1.94
	Income	Upper 50%	Ref		Ref		Ref	
		Lower 50%	1.01	0.82-1.24	1.40	1.10-1.78	1.28	0.97-1.68
	Insurance	Yes	Ref		Ref		Ref	
		No	1.02	0.83-1.26	1.29	1.02-1.64	1.30	1.00-1.69
Working Time Arrangement[g]		Regular	Ref		Ref		Ref	
		Irregular	1.30	1.05-1.61	1.22	0.99-1.50	1.27	1.00-1.61
	Shift	Day Shift	Ref		Ref		Ref	
		Not Day Shift	1.10	0.86-1.41	1.08	0.85-1.38	1.11	0.84-1.45
	Hours Per Day	≤ 8	Ref		Ref		Ref	
		> 8	1.41	1.07-1.86	1.23	0.93-1.61	1.32	0.97-1.81
Employability Opportunities[h]		Yes	Ref		Ref		Ref	
		No	0.82	0.59-1.14	0.88	0.65-1.19	0.85	0.59-1.21
Collective Organization[i]		Yes	Ref		Ref		Ref	
		No	0.84	0.60-1.19	0.88	0.63-1.24	0.89	0.59-1.34
Employment Precarity[j]		Low	Ref		Ref		Ref	
		Medium	1.06	0.82-1.37	1.24	0.96-1.60	1.36	1.01-1.82
		High	1.03	0.82-1.29	1.32	1.03-1.70	1.48	1.11-1.98
		Continuous	1.02	0.93-1.11	1.12	1.02-1.23	1.17	1.05-1.30

[a] NLSY79: National Longitudinal Survey of Youth 1979
[b] Unadjusted generalized linear model of employment precarity and low birthweight
[c] Model adjusted for maternal age, maternal race/ethnicity, maternal educational attainment, maternal nativity, and infant year of birth
[d] Model adjusted for all covariates in model 2 plus maternal pre-pregnancy BMI, maternal smoking during pregnancy, and maternal alcohol consumption during pregnancy
[e] RR: Risk Ratios
[f] 95% CI: 95% Confidence Intervals
[g] Women with regular working times had a day shift and worked ≤ 8 hours per day. Women with irregular working times had a non-day shift or worked more than 8 hours per day or had both
[h] Employability opportunities was defined as having employer provided trainings or education
[i] Collective organization was defined as union membership
[j] Employment precarity was categorized based on scores from an index of individual employment characteristics; low: 0-2, medium: 3, high: 4-6

The categorical precarity measure was positively associated with LBW after adjusting for confounders. Women with high and medium employment precarity were more likely to have a LBW infant compared to low employment precarity, after adjustment for all covariates (RR: 1.48, CI: 1.11, 1.98 and 1.36 CI: 1.01, 1.82, respectively). The continuous measure of precarity

showed a 1.17 (CI: 1.05, 1.30) times higher risk for LBW for a one point higher value in precarity after adjustment for all covariates.

We evaluated effect modification of the employment precarity-LBW association by race. The magnitude of the parameter estimates suggest that Non-Hispanic Black women had elevated LBW risk across all employment precarity levels compared to non-Hispanic/non-Black women with low employment precarity (Non-Hispanic Black low precarity: 1.66, CI: 1.08, 2.57; medium precarity: 3.04, CI: 1.87, 4.95; high precarity: 2.68, CI: 1.72, 4.15) (Table 4). Hispanic mothers also had higher risk when compared to non-Hispanic/non-Black women with low precarity (Hispanic low precarity: 1.79, CI: 1.13, 2.84; high precarity: 2.53, CI: 1.54, 4.16). The supplemental table provides estimates comparing low precarity to the combined medium and high precarity group. These results are similar in magnitude to Table 4, but have improved precision.

Table 4. Risk ratios and 95% Confidence Intervals for the Association Between the Composite Employment Precarity Variable and Low Birth Weight by Maternal Race/Ethnicity in the NLSY79[a] Cohort (1979-2007)[b]

Employment Precarity	Non-Hispanic /non-Black			Hispanic			Non-Hispanic Black		
	RR[c]	95%CI[d]	N	RR[c]	95%CI[d]	N	RR[c]	95%CI[d]	N
Low Precarity	Ref		831	1.79	1.13-2.84	212	1.66	1.08-2.57	262
Medium Precarity	1.34	0.91-1.99	406	1.65	0.87-3.12	95	3.04	1.87-4.95	106
High Precarity	1.46	0.98-2.16	539	2.53	1.54-4.16	188	2.68	1.72-4.15	232

[a] NLSY79: National Longitudinal Survey of Youth 1979
[b] Models are adjusted for maternal age, infant year of birth, maternal educational attainment during pregnancy, maternal nativity, maternal pre-pregnancy BMI, maternal smoking during pregnancy, and maternal alcohol consumption during pregnancy
[c]RR= Risk Ratios
[d]95% CI= Confidence Intervals

DISCUSSION

In this study, we found that women with high employment precarity in the wave prior to or during pregnancy had a higher risk of giving birth to an LBW infant than women with low employment precarity. Of the individual employment characteristics examined, low material rewards and irregular working time arrangements were associated with LBW. This elevated risk of LBW may be the result of employment-related stress or lack of access to resources due to these specific employment characteristics.

In addition, we found effect modification by maternal race/ethnicity, with elevated LBW risk in all employment precarity groups in Non-Hispanic Black women and the low and high employment precarity groups in Hispanic women when compared to non-Hispanic/non-Black women with low precarity. Though the medium precarity Hispanic group did not have significant findings, this may be the result of a lack of statistical power. This suggests that health inequities exist between these subpopulations and could be a result of different stressors from employment precarity or a combination of workplace and additional life stressors, such as racism and discrimination that women of color disproportionately experience. Furthermore, our results suggest that employment precarity may be one mechanism by which race/ethnic disparities in low birth weight occur. Labor market stratification results in more women and people of color being employed in precarious employment [41]; thus suggesting the importance of employment precarity as a mechanism by which health disparities are created and maintained. We are unable to test this hypothesis in our study, however; work in progress by our research team will examine this question in depth.

Our study is the first to investigate the association between a multidimensional maternal employment precarity construct and infant LBW. Findings were similar to studies examining traditional job stressors, such as job demand/control, that showed higher risk for adverse birth outcomes, such as LBW and preterm birth, in those with poorer quality jobs.[15,24,36] Some

older studies and studies conducted outside of the United States did not find job stressors increased the risk for preterm birth and small for gestational age, suggesting that national and temporal contexts may influence the work—pregnancy outcome association.[45,46] This study adds to a growing body of literature that aims to characterize multiple facets of employment quality which extends beyond the more traditional models of job stress, which focus on the psychosocial work environment.[23,47] This study also adds to the literature on inequities in birth outcomes between racial/ethnic groups in the United States and emphasizes the choice of reference groups when conducting research in regard to inequities.[26,28,33,34]

Our study has several limitations. First, there is incomplete ascertainment of precarity as laid out by our conceptual framework.[26,27] In particular, data within the NLSY for the dimensions of employment stability, interpersonal power relations, and workers' rights and social protections is lacking; this is a part of a broader issue that few datasets have robust information on employment precarity. It is also possible that the existing variables we use to define the dimensions of precarity may not fully capture those dimensions. Additional research on defining precarity, specifically in the US context, is needed to better evaluate the measurement of this multi-dimensional construct. Second, misclassification of the exposure may have resulted from our approach to missing data, in which we used data from the year prior to populate missing data for a subsequent year. In a related concern, we explored multiple imputation methods for the material rewards dimension, but decided against it as both the amount of missing data (around 10% unweighted) and the likely pattern of missing data (not missing at random) cannot be accommodated by most statistical software packages . [48] Regardless, some bias may result from missing data. Further, due to a lack of information on exact date of birth, precarity measures were taken in the interview cycle preceding the year of birth, thus may represent employment occurring as little as a few months before the child's birth to as much as 3 years prior to the birth. Therefore, the exposure may represent different clinically relevant time

points for each participant. Also related to exposure misclassification, we do not believe that validity of self-reported employment characteristics would differ between outcome groups; thus resulting in nondifferential misclassification. Although on *average* non-differential misclassification attenuates estimates towards the null, this may not be the case in our study given the other potential sources of bias. [49, 50] Another source of potential misclassification lies in the self-reported outcome data; however, a past study found high correlation between maternal recall of infant birth weight many years after pregnancy and birth weight obtained during pregnancy.[51] Though some infants may be LBW as a result of a preterm birth, we did not have information on gestational age and could not distinguish between full term LBW and preterm LBW infants, which may be important as these two birth outcomes may have different etiological pathways. Residual and unmeasured confounding was also a limitation. Data on pregnancy risk factors, partner's employment status, their fringe benefits and social support networks may also have been important unmeasured confounders. Sample sizes for racial and ethnic groups were small when assessing differences in the employment precarity-LBW association by subgroup, thus impacting our power to detect an effect. The NLSY uses a stratified random sampling approach, where participants are recruited only from certain areas of the nation. This clustering can bias our results, as people living in certain neighborhoods may be more similar to each other than those living in different areas. In essence, this is a violation of the independence assumption applicable to most regression modelling approaches. Given our study population, the only approach to adjusting for clustering would be to gain access to the restricted geocoded data. We were unable to do this, thus we recognize that clustering may bias our results. The direction of bias, however, is predictable. Accounting for clustering will inflate the standard errors, but should have minimal effect on the point estimates. Thus the true confidence intervals will likely be wider than what is presented in Table 3 and 4, which in some cases may result in non-statistically significant estimates. Thus we urge readers to view our regression results with healthy skepticism. Finally, sampling for this study was based on the

population residing in the United States in 1979 and was employed during or prior to pregnancy. It may not be representative to today's sociodemographic distribution, or to the risk of LBW for those without a job or searching for employment.

Future research should focus on elucidating the employment precarity–LBW relationship through a more complete ascertainment of the exposure, including indicators from all seven precarity dimensions and a better assessment of the most relevant maternal employment period (e.g. prior to or concurrent with pregnancy) for birth outcomes. Researchers interested in employment precarity and birth outcomes may also consider including data on things such as availability of paid family leave as these types of policies are of particular relevance to women as well as oversampling racial/ethnic groups to assess differences in subpopulations. Investigating the role of paternal employment precarity as an exposure for adverse birth outcomes may also be a fruitful avenue of research. Because the data we used did not distinguish between unemployed individuals looking for paid work and those not seeking employment, we could not include a reference group of women seeking employment. However, future research should consider including these women as a reference group, especially in an effort to further understand the gig economy.

Our findings support greater examination of employment precarity and health, especially as a larger proportion of women enter and remain in the workforce. The findings from studies of employment precarity could better inform prenatal care for working women. Clinicians treating women who plan to work during their pregnancy should consider asking their patients about their employment conditions and recommend resources that may mitigate the effects of employment precarity. Potential workplace policies or practices, such as altering working times or ensuring benefits to pregnant employees may also support women during their pregnancy; however, we need rigorous studies that directly examine the impact of policies on birth outcomes to truly understand the effect of such policies.

CONCLUSION

Our study uses a multidimensional definition of precarious employment. We found that women with higher employment precarity had higher risk of LBW. Non-Hispanic Black and Hispanic women had elevated risk of LBW across levels of precarious employment. Our findings may inform workplace policies to better support women during pregnancy.

Author's Contribution

Ms. Patil was responsible for analysis and interpretation of the data as well as writing the paper.

Dr. Enquobahrie substantively revised the manuscript for important intellectual content.

Mr. Peckham contributed to the conception of the study and substantively revised the manuscript for important intellectual content.

Dr. Seixas substantively revised the manuscript for important intellectual content.

Dr. Hajat conceived and designed the study, conducted additional data analysis and contributed to interpretation of data. She also substantively revised the manuscript and oversaw the project.

All authors reviewed and approved of the submitted version and are accountable for ensuring accuracy and integrity of the work.

There is no one else who fulfils the criteria that has been excluded as an author.

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Data Availability

Data is publicly accessible through the United States Bureau of Labor Statistic's website for National Longitudinal Surveys: https://www.nlsinfo.org/content/cohorts/nlsy79/get-data.

Figure 1. Exclusion criteria for participants in the NLSY79 cohort (1979-2007)

References

1 Wang SF, Shu L, Sheng J et al. Birth weight and risk of coronary heart disease in adults: a meta-analysis of prospective cohort studies. *Journal of Developmental Origins of Health and Disease* 2014;5:408-19.

2 Zarrati M, Shidfar F, Razmpoosh E et al. Does low birth weight predict hypertension and obesity in schoolchildren? *Ann Nutr Metab* 2013;63:69-76.

3 McCormick MC. The Contribution of Low Birth Weight to Infant Mortality and Childhood Morbidity. *N Engl J Med* 1985;312:82-90.

4 Hack M, Flannery DJ, Schluchter M, Cartar L, Borawski E, Klein N. Outcomes in Young Adulthood for Very-Low-Birth-Weight Infants. *N Engl J Med* 2002;346:149-57.

5 Behrman JR, Rosenzweig MR. Returns to Birthweight. *The Review of Economics and Statistics* 2004;86:586-601.

6 Martin JA, Hamilton BE, Osterman MJ, Discoll AK, Drake P. Births: Final data for 2016 2018.

7 Bernabé JVd, Soriano T, Albaladejo R et al. Risk factors for low birth weight: a review. *European Journal of Obstetrics and Gynecology and Reproductive Biology* 2004;116:3-15.

8 United States Department of Labor. Women's Bureau (WB) - Women in the Labor Force.

9 Mathews TJ, Hamilton BE. Mean Age of Mothers is on the Rise: United States, 2000-2014. *NCHS data brief* 2016:1-8.

10 Burdorf A, Figà-Talamanca I, Jensen TK, Thulstrup AM. Effects of occupational exposure on the reproductive system: core evidence and practical implications. *Occup Med* 2006;56:516-20.

11 Figà-Talamanca I. Occupational risk factors and reproductive health of women. *Occup Med* 2006;56:521-31.

12 Henriksen TB, Hedegaard M, Secher NJ. Standing and walking at work and birthweight. *Acta Obstet Gynecol Scad* 1995;74:509-16.

13 Florack EI, Pellegrino AE, Zielhis GA, Rolland R. Influence of occupational physical activity on pregnancy duration and birthweight. *Scandinavian Journal of Work, Environment & Health* 1995;21:199-207.

14 Palmer KT, Bonzini M, Harris EC, Linaker C, Bonde JP. Work activities and risk of prematurity, low birth weight and pre-eclampsia: an updated review with meta-analysis. *Occup Environ Med* 2013;70:213-22.

15 Katz VL. Work and Work-related Stress in Pregnancy. *Clin Obstet Gynecol* 2012;55:765-73.

16 Lee B-E, Ha M, Park H et al. Psychosocial work stress during pregnancy and birthweight. *Paediatr Perinat Epidemiol* 2011;25:246-54.

17 Karasek RA. Job Demands, Job Decision Latitude, and Mental Strain: Implications for Job Redesign. *Adm Sci Q* 1979;24:285-308.

18 Peckham TK, Baker MG, Camp JE, Kaufman JD, Seixas NS. Creating a Future for Occupational Health. *Annals of Work Exposures and Health* 2017;61:3-15.

19 Weil D. *The fissured workplace: Why work became so bad for so many and what can be done to improve it*. Cambridge, Massachusetts London: Harvard University Press, 2014.

20 Bosch G. Towards a New Standard Employment Relationship in Western Europe. *British Journal of Industrial Relations* 2004;42:617-36.

21 Kalleberg AL. *Good jobs, bad jobs: the rise of polarized and precarious employment systems in the United States, 1970s to 2000s*. New York, NY: Russel Sage Foundation, 2013.

22 Benach J, Vives A, Amable M, Vanroelen C, Tarafa G, Muntaner C. Precarious Employment: Understanding an Emerging Social Determinant of Health. *Annu Rev Public Health* 2014;35:229-53.

23 Scott-Marshall H, Tompa E. The health consequences of precarious employment experiences. *Work* 2011;38:369-82.
24 Dooley D, Prause J. Birth Weight and Mothers' Adverse Employment Change. *J Health Soc Behav* 2005;46:141-55.
25 Kalleberg AL. Precarious Work, Insecure Workers: Employment Relations in Transition. *Am Sociol Rev* 2009;74:1-22.
26 Julià M, Vanroelen C, Bosmans K, Van Aerden K, Benach J. Precarious Employment and Quality of Employment in Relation to Health and Well-being in Europe. *Int J Health Serv* 2017;47:389-409.
27 Eurofound. Quality of Employment Conditions and Employment Relations in Europe *Eurofound, Dublin, Ireland* 2013.
28 Lewchuk W, Clarke M, de Wolff A. Working without commitments: precarious employment and health. *Work, Employment and Society* 2008;22:387-406.
29 Sandman CA, Wadhwa PD, Dunkel-Schetter C et al. Psychobiological Influences of Stress and HPA Regulation on the Human Fetus and Infant Birth Outcomesa. *Ann N Y Acad Sci* 1994;739:198-210.
30 O'Donnell K, O'Connor TG, Glover V. Prenatal Stress and Neurodevelopment of the Child: Focus on the HPA Axis and Role of the Placenta. *Dev Neurosci* 2009;31:285-92.
31 Sandman CA, Wadhwa PD, Chicz-DeMet A, Dunkel-Schetter C, Porto M. Maternal Stress, HPA Activity, and Fetal/Infant Outcomea. *Ann N Y Acad Sci* 1997;814:266-75.
32 Tompa E, Scott-Marshall H, Dolinschi R, Trevithick S, Bhattacharyya S. Precarious employment experiences and their health consequences: Towards a theoretical framework. *Work* 2007;28:209-24.
33 Lane SD, Keefe RH, Rubinstein R et al. Structural violence, urban retail food markets, and low birth weight. *Health & Place* 2008;14:415-23.
34 Luo Z-C, Wilkins R, Kramer MS. Effect of neighbourhood income and maternal education on birth outcomes: a population-based study. *CMAJ* 2006;174:1415-20.
35 Phillippi JC. Women's Perceptions of Access to Prenatal Care in the United States: A Literature Review. J Midwifery Womens Health. 2009 May 6;54(3):219–25.
36 Casas M, Cordier S, Martínez D et al. Maternal occupation during pregnancy, birth weight, and length of gestation: combined analysis of 13 European birth cohorts. *Scandinavian Journal of Work, Environment & Health* 2015;41:384-96.
37 Larsen AD, Hannerz H, Juhl M et al. Psychosocial job strain and risk of adverse birth outcomes: a study within the Danish national birth cohort. *Occup Environ Med* 2013;70:845-51.
38 Lu MC, Halfon N. Racial and Ethnic Disparities in Birth Outcomes: A Life-Course Perspective. *Maternal and Child Health Journal* 2003;7:13-30.
39 Cramer JC. Racial and Ethnic Differences in Birthweight: The Role of Income and Financial Assistance. *Demography* 1995;32:231-47.
40 Menéndez M, Benach J, Muntaner C, Amable M, O'Campo P. Is precarious employment more damaging to women's health than men's? *Soc Sci Med* 2007;64:776-81.
41 Hipple S. Contingent Work in the Late-1990s. *Mon Labor Rev* 2001;124:3.
42 Kott PS. Clarifying some issues in the regression analysis of survey data. InSurvey Research Methods 2007 Jan 29 (Vol. 1, No. 1, pp. 11-18).
43 Solon G, Haider SJ, Wooldridge JM. What are we weighting for?. Journal of Human resources. 2015 Mar 31;50(2):301-16.
44 VanderWeele TJ, Knol MJ. A Tutorial on Interaction. *Epidemiologic Methods* 2014;3:33-72.
45 Larsen AD. The effect of maternal exposure to psychosocial job strain on pregnancy outcomes and child development. *Danish Medical Journal* 2015;62.

46 Homer CJ, Beresford SAA, Jarnes SA, Siegel E, Wilcox S. Work-related physical exertion and risk of preterm, low birthweight delivery. *Paediatr Perinat Epidemiol* 1990;4:161-74.

47 Vives A, Amable M, Ferrer M et al. The Employment Precariousness Scale (EPRES): psychometric properties of a new tool for epidemiological studies among waged and salaried workers. *Occup Environ Med* 2010;67:548-55.

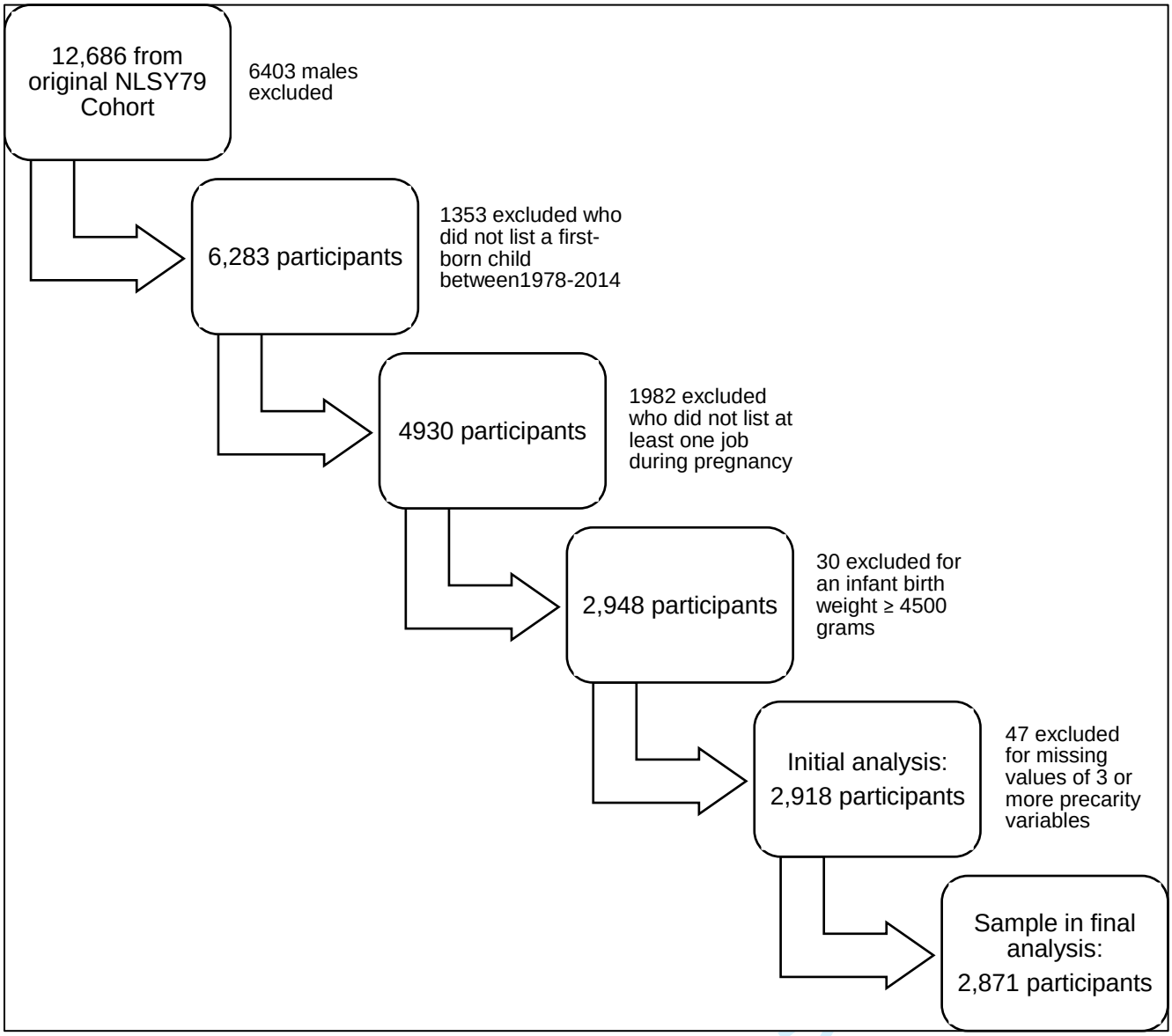
48 Dong Y, Peng CY. Principled missing data methods for researchers. SpringerPlus. 2013 Dec 1;2(1):222.

49 Jurek AM, Greenland S, Maldonado G, Church TR. Proper interpretation of non-differential misclassification effects: expectations vs observations. International journal of epidemiology. 2005 Mar 31;34(3):680-7.

50 Jurek AM, Greenland S, Maldonado G. Brief report: how far from non-differential does exposure or disease misclassification have to be to bias measures of association away from the null?. International journal of epidemiology. 2008 Jan 8;37(2):382-5.

51 Tomeo CA, Rich-Edwards JW, Michels KB et al. Reproducibility and Validity of Maternal Recall of Pregnancy-Related Events. *Epidemiology* 1999;10:774.

Figure 1. Exclusion Criteria for Participants in the NLSY79 Cohort (1979-2007)



Supplementary File

Table S1. Risk ratios and 95% Confidence Intervals for the Association Between the 2-level Composite Employment Precarity Variable and Low Birth Weight in the NLSY79[a] Cohort (1979-2007)

		Model 1 [b]		Model 2 [c]		Model 3 [d]
	RR [e]	95% CI [f]	RR [e]	95% CI [f]	RR [e]	95% CI [f]
Low Employment Precarity[j]	Ref	Ref	Ref	Ref	Ref	Ref
Medium and High Employment Precarity[j]	1.04	0.84, 1.29	1.28	1.02, 1.61	1.42	1.10,1.84

a NLSY79: National Longitudinal Survey of Youth 1979
b Unadjusted generalized linear model of employment precarity and low birthweight
c Model adjusted for maternal age, maternal race/ethnicity, maternal educational attainment, maternal nativity, and infant year of birth
d Model adjusted for all covariates in model 2 plus maternal pre-pregnancy BMI, maternal smoking during pregnancy, and maternal alcohol consumption during pregnancy
e RR: Risk Ratios
f 95% CI: 95% Confidence Intervals

Table S2. Risk ratios and 95% Confidence Intervals for the Association Between the 2-level Composite Employment Precarity Variable and Low Birth Weight stratified by Maternal Race/Ethnicity in the NLSY79 [a] Cohort (1979-2007)[b]

	Non-Hispanic/ non-Black			Hispanic			Non-Hispanic Black		
	RR[c]	95%CI[d]	N	RR[c]	95%CI[d]	N	RR[c]	95%CI[d]	N
Low Employment Precarity	Ref	Ref	831	1.08	0.61, 1.90	212	1.28	0.79, 2.07	262
Medium & High Employment Precarity	0.83	0.48, 1.44	945	0.64	0.38, 1.09	283	1.78	1.09, 2.91	338

a NLSY79: National Longitudinal Survey of Youth 1979

b Model adjusted for all covariates in model 2 plus maternal pre-pregnancy BMI, maternal smoking during pregnancy, and maternal alcohol consumption during pregnancy

c RR: Risk Ratios

d 95% CI: 95% Confidence Intervals

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6-10
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6-7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-9
Bias	9	Describe any efforts to address potential sources of bias	8,9
Study size	10	Explain how the study size was arrived at	Fig. 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9,10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9,10
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, explain how loss to follow-up was addressed	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6,7
		(b) Give reasons for non-participation at each stage	6,7
		(c) Consider use of a flow diagram	Fig. 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10,11
		(b) Indicate number of participants with missing data for each variable of interest	11-12
		(c) Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13,14
		(*b*) Report category boundaries when continuous variables were categorized	7-9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14,15
Discussion			
Key results	18	Summarise key results with reference to study objectives	15
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	16,17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	3

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.